5-2021

Teacher practices with adaptive math technology: Sitting in the driver’s seat of a self-driving car

Jennifer Longnecker
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To the Graduate Council:

I am submitting herewith a dissertation written by Jennifer Longnecker entitled "Teacher practices with adaptive math technology: Sitting in the driver's seat of a self-driving car." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Amy Broemmel, Major Professor

We have read this dissertation and recommend its acceptance:

Joshua Rosenberg, Jennifer A. Morrow, Elizabeth R. MacTavish

Accepted for the Council:

Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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A Dissertation Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Jennifer Lawson Longnecker
May 2021

Dedication

The crescendo of this dissertation has been lined with the love and support of my family and friends. My three children have each contributed something different to this journey and I am forever grateful to them.

My son, Josh, and his ever-eternal belief in me, pushed me to live up to how he sees me. He has taught me how to be genuine, kind, and brutally honest with myself. He has always known what I needed to hear even when I didn't know myself. His humor and unique take on life and situations, has kept me laughing through life's challenges. This journey would not have been possible without him.

My daughter, Ashley, is a constant reminder of strength and endurance. Joan Rivers once said, "I didn't realize when I gave birth to my daughter that I was also giving life to my best friend." Our journey together has not always been easy, but it certainly has been worth it. Ashley has shown me how adversity does not define you; it is the catalyst that prods you to grow and change and evolve into who you want to be.

My son, Ben, has stood at my back and pushed me forward when I felt like slowing down. His honesty and realism have kicked me back into play when I felt like heading for the sidelines. He is a constant reminder of what we all are for each other in life and how we are not only expected but charged with the responsibility of caring for those around us.

Although I acknowledge the love and endless support my children have given me, I dedicate this dissertation to myself. I certainly have a debt of gratitude to them I can never repay; I didn't write this dissertation for them. I completed this life journey for myself.

Acknowledgements

To my dissertation chairs, Dr. Amy Broemmel and Dr. Joshua Rosenberg: this sojourner thanks you for making this challenging expedition so worthwhile. To Dr. Broemmel, thank you for three full years of unwavering support. Your authenticity and compassion for all doctoral students is appreciated at a deep level and your knowledge of research and education has enriched my thinking and work in a profound way. Thank you. To Dr. Rosenberg, thank you for including me in your research group, introducing me to quality educational researchers and guiding me through the revision process that, no doubt, will continue through my quest for publications. Thank you.

To the rest of my committee, who have shown immense support for me in all phases of this program. To Dr. Jennifer Morrow, who cared enough to leave my first assignment in her class in a state of bleeding, red pen marks so profound, I thought I was in the wrong profession, only to guide me through revisions to a product she said was publishable. I am grateful. To Dr. Elizabeth MacTavish, who has taught me so much through example. I feel thankful to have been your GTA, as you made me feel like a partner in teaching, valued my input, and gave me guidance all along the way. Thank you. To Dr. Blanche O'Bannon, Committee Member Emeritus. You are an amazing example of strength and resilience. I will be eternally thankful to you for showing me how to pick yourself up, focus on a goal, move forward, and never look back. Thank you.

To my family and friends, who never tired of listening to the stories of my experiences in coursework, research, and writing. Those were mostly ramblings of a crazy person. To my children whose love and support never dimmish. To my friend, John, who taught me to turn left. I will be forever grateful for your love and friendship, given freely and authentically. To the many friends who supported me even when it wasn't easy, Karla, Carol, Regina, Lyn, Andie, as well as countless others. And to my cubemate, Matt Hensley (no, Matt, this does not count as a citation), and cohort bestie, Amanda Rigell, we are forever connected by this experience.

Lastly, I would like to thank the Delta Sky Club for the countless bowls of oatmeal, gallons of hummus, hundreds of brownies, and free flowing soda water. For three years I have used your WIFI and comfortable seating to write endlessly in pursuit of this dissertation. Thank you.

Abstract

The 21st century has seen adaptive math technology (AMT), often formatted as digital game-based learning, integrated into a greater number of elementary classrooms as students have more access to devices than ever before. This study explores the practices of *power users*, teachers who are highly effective users and integrators of that technology. Specifically, the top ten percent of users of the adaptive math program, DreamBox, were surveyed (n = 117) about their practices and routines when integrating the AMT. The results of this study contribute to teacher practices for integrating this technology into the K-5 classroom. The findings show teachers with the highest amount of average student growth deliberately schedule time daily for program use, have time and/or lesson requirements for their students, give rewards (often in the form of public acknowledgment), and hold their students accountable for their progress in learning. When these power users view individual student data on the program's dashboard, the practices they engage in most often are viewing the student's total amount of time using the program and lessons completed. When viewing the class as a whole, they view lessons completed and total standards completed. The teachers reported they use the AMT most often for student review of content from the current grade and additional practice of that content, essentially pairing the lessons students engage in the program with what they are presently teaching. This study establishes the practices of highly effective teachers for using AMT in the classroom as: (1) pairing lessons with current content being taught, (2) having daily scheduled time for AMT, (3) time/lesson requirement for students, (4) a system of rewards & accountability, (5) assigning lessons to fill in gaps & enrichment, and (6) identifying students struggling & holding help sessions.

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Chapter 1
Introduction

The 21st century is here, and our classrooms must reflect a new standard of teaching. The modern classroom is a meaningful learning environment where rigorous content and authentic collaboration with a multitude of technologies can combine to provide deeper learning of the skills and knowledge needed for 21st century success (Qian et al., 2016). Collaboration, critical thinking, and creativity in problem solving are vital for contemporary students (Binkley et al., 2014). To effectively teach these skills to the masses, it is not enough for teachers to simply use the traditional, pedagogical teaching practices; teachers must do more. Teachers are charged with the responsibility to integrate all available resources—including computer-driven technologies—to ensure that their students are prepared for the evolving challenges facing our society.

While past generations of teachers did not readily have access to computer-driven technologies, these advancements have become more prevalent in all classrooms (Cheung et al., 2012). Technology integration into the classroom has been found to increase student achievement, especially in content areas such as math and science, by providing more authentic learning experiences (Cheung et al., 2013; Zheng et al., 2016). Many teachers and school districts have embraced technology as a positive learning tool for students in the K-12 environment (Varier et al, 2017). With technology becoming commonplace in elementary classrooms, some schools have purchased adaptive math technology (AMT). AMT assesses a student's concept knowledge and assigns game-like lessons and activities to either reinforce skills, reteach missing concepts, or expose the student to new concepts (Pelletier, n.d.). Furthermore, research has found game-like, AMT has a positive effect on student learning (Cheung et al., 2013).

These programs continuously assess a student's mathematical needs and adapt the content to meet those needs (Retalis et al., 2005). Most game-like, adaptive math programs are student-centered, student-driven, and, many times, are used in isolation from the curriculum and apart from any teacher involvement (Smith, 2018). These adaptive math programs are like self-driving cars—*i.e.,* no teacher needed. But what happens when a teacher deliberately "sits in the driver's seat" and takes control of a program?

"Sitting in the driver's seat" requires the teacher to understand not only how the adaptive program works, but also how it fits pedagogically and contextually within the overall framework of the classroom instructional model. Though learning how to use these tools may seem daunting to many already-overworked teachers, the potential for individualized growth for students is limitless. For example, if the daily lesson is fractions and the teacher determines a student is struggling the larger concept of units, the teacher can remove the AMT lesson assigned to that student and replace it with a fundamental concept lesson of units to address the gap in the student's understanding. By pairing the program with the content currently being taught, the teacher is essentially giving the needed, individualized attention to a struggling student—without compromising the growth of the class as a whole. Simply speaking, a teacher has two options for an AMT: (1) a teacher can passively allow these programs to run their natural algorithm-generated course; or (2) a teacher can use these programs to actively and deliberately target the needs of each student. Any teacher choosing option one may be missing a valuable opportunity to bring the benefits of the powerful tools of our modern era to all students.

Background

I used technology in every part of my elementary classroom teaching. It assisted in keeping my classroom organized, efficient, and student-centered, but most importantly, technology served as a learning tool for students. As part of our curriculum, my 4th grade students were required to complete lessons in a digital game-based learning (DGBL) program. DGBL is an AMT that uses gameplay to teach concepts through a digital platform. I found the program so powerful and so data rich that I invested a large amount of my time to fully learn the program and its capabilities and made sure my students understood how the program worked as well. Seeing the standards my students completed (or struggled with) and the conceptual knowledge they still lacked, drove how I engaged with the program. As I began to drive the program, I was able to assign lessons and remove lesson as needed, based on the educational needs of the individual student as opposed to letting the adaptive aspect of the program assign lessons. Implementing the curriculum provided by the school district and interacting to a greater degree with the features the AMT provided, I watched my students grow in their conceptual confidence and knowledge. I explored the data extensively and used it to drive my intervention with the program. Making sure my students were motivated to spend the time needed to see a large amount of growth in their math conceptual knowledge and skills, was also a top priority. This combination of both student motivators and teacher involvement through active game manipulation led to exponential, overall class growth by the end of the school year. By the end of the year, my students achieved an average of over 200% growth (100% growth being roughly equivalent to one school year).

Purpose

Although studies in adaptive math technology have examined effectiveness of the individual programs, there are few studies with a focus on teacher involvement in these student-centered programs (Yeh et al, 2019). Therefore, the purpose of this study is to examine the practices of highly effective teachers with AMT in an attempt to describe the teacher practices that influence student growth as measured in the adaptive math program. This study will establish the teaching practices they employ when interacting with AMT.

Additionally, this study seeks to establish when highly effective teachers interact with AMT, whether their focus is on the class as a whole or the individual student.

Significance

This study contributes to the literature from both practical and theoretical standpoints. It will address the gap in the literature related to how teachers use AMT in their classrooms. From the perspective of practice, this study informs teachers of the practices that contribute to greater student growth and enumerates what practices highly effective teachers engage in with AMT. Furthermore, the findings from this study contribute to the development of effective professional development that provides K-6 teachers with necessary knowledge and skills to collaborate with AMT in a way that increases student outcomes. Targeted teacher practices would contribute to more amalgamated use of AMT with the curriculum instead of a stand-alone supplemental learning tool.

Research Questions

There is evidence of the effectiveness of game-based learning in the classroom (An et al., 2016; Cheung et al., 2013; Yeh et al., 2019). While past research has shown teachers have a desire and need for professional development on how to integrate AMT and how to interact with the technology (Callahan et al., 2018; An et al., 2016) studies have not explored the most effective teacher practices with AMT, this study seeks to add to the literature the teacher practices that are the most effective for increasing student growth with AMT. This gap is important because AMT is shown to be effective in increasing student outcomes, school districts are increasingly adding this technology to the 21st century classroom, student access to technology at school and at home is increasing, and teachers have a desire to learn how to use and integrate AMT in their classroom. Given the current lack of research into the influence teachers have with adaptive math technology, there still remain some questions. The study includes the following questions:

1. What practices do highly successful teachers enact when using adaptive math technology?

    1a. When teachers interact with the AMT, do they focus on the class as a whole or individual student?

Delimitations

The boundaries set for this study include using a single AMT, DreamBox. In addition, this study is only looking at highly successful teachers from one school year. This time frame is used to focus on the most current teacher practices with AMT, as educational technology evolves relatively quickly, so do the associated teacher practices.

Limitations

I will be collecting data via a survey administered during a pandemic; a year characterized by a virtual learning environment and, in some cases, an unpredictable cessation of regular classes. This follows a previous school year when some classes were moved to an online environment or discontinued altogether for the last quarter of the school year (Peele et al, 2020). As such, what teachers are doing now with AMT may not mirror what they were doing before the pandemic.

Assumptions

Several assumptions are considered in this study. I assume the teachers completing the survey are highly effective at interacting with and incorporating the AMT platform into their classroom. I am assuming the practices of power users with the AMT are effective. Since the survey is only targets those teachers who have had the most success with the program, I assume their practices are contributing to high student growth.

Additionally, because the link to the research survey is given to an AMT software company and they will be forwarding the link to their program's power users, those who get the highest average student growth in a school year, the participant's data is not directly used. I am relying on the software company to only give the survey link to those highest producing users, teachers whose average student growth is in the top 10% in their respective grade level.

Definitions of Key Terms

This section provides definitions for key terms used and applied in the context of this study.

21st century classroom — A classroom where the skills needed for the careers students most likely will encounter are not only taught but nurtured and seamlessly integrated into their everyday learning. This classroom is student-focused and student-centered and the teacher acts as the facilitator. In addition, less emphasis is on memorization and textbooks and more emphasis is on higher order thinking skills and technology (Partnership for 21st Century Learning, 2007).

Adaptive math technology — A computer program that continuously assesses the student's mathematical needs and adapts the content to meet those needs (Retalis et al., 2005). Most adaptive math programs are student-centered, student-driven, and are sometimes used in isolation from the curriculum and even apart from any teacher intervention (Smith, 2018).

Computer assisted instruction — A program a student engages with individually. The computer program provides the instruction through simulations, drill and practice, tutorials, and gaming (Aydin, 2005; Slavin, 2007).

Computer-managed learning system — Computer programs used to assess student needs, work, and outcomes. These assessments are communicated to teachers. These programs are supplemental to curriculum and used to enrich student learning (Slavin, 2007).

Dashboard — In the context of this study, a dashboard refers to the main screen of the adaptive math technology (in this case DreamBox) that houses learning activity and data. In this central location teachers and students can find information about connections to curriculum and standards as well as track learning progress. The dashboard contains different features for teachers and students, with the student dashboard containing grade appropriate information and the teacher dashboard providing rich data regarding student achievements and progress (Verbert et al, 2014).

Digital game-based learning — Game play used to learn concepts and skills through a digital platform. Gee (2005) believes "it is something about how games are designed to trigger learning that makes them so deeply motivating," encouraging students to keep playing. The Federation of American Scientists (2006), during the National Summit on Educational Games in 2005, gave digital games for education praise for the skills and concepts they can teach, most notably, strategic thinking, analytical thinking, decision making, problem solving, and adaption to change.

Digital natives — A generation that has grown up surrounded by technology used in an authentic way and integrated into their daily lives (Prensky, 2001).

DreamBox Learning — An AMT online software provider that focuses on K-8, math education through an intelligent adaptive environment using digital game-based learning. Founded in 2006, this software uses animated games, adventures, and challenges to teach math concepts as well as provide practice for skills and knowledge (DreamBox Learning, 2014).

Game-based learning — Capitalizing on the highly engaging nature of game play, students learn concepts and skills through games. Games can deliver high quality learning opportunities (Gee, 2005). Engagers in game play often use problem solving, reasoning, and collaboration to reach a goal or triumph over another player (Gee, 2005).

Power users — Power users are teachers who have the most growth in the AMT program used in this study. The participants are teachers whose average student growth is in the top 10% in their respective grade level as measured in the program at the time of the survey.

Student-centered learning — An educational environment where the student is the focus of the learning. The students can feel a sense of autonomy and have an increased sense of responsibility, accountability, and are active participants in their learning (Lea et al., 2003).

Student growth (DreamBox) — This is the amount of progress a student makes across all of DreamBox curriculum, including all domains and grade levels. Students obtain growth by completing lessons proficiently (DreamBox Learning, 2021).

Positionality Statement

As a former 4th grade math teacher in a suburban school district and a former 1st grade teacher in an urban school district, I recognize the vast differences that can sometimes be a factor when students interact with AMT. Due to a lack of resources, some school districts do not have the funds to purchase an AMT. With this in mind, when I started teaching at a school that did have the resources to purchase an AMT program, DreamBox, I researched its capabilities, functionality, and became a power user, a teacher who has exceptional student growth within the program. I was a teacher who was able to use my knowledge of how the program worked to create exponential student growth within the program. As a power user, I helped other teachers in my school, hosted professional development for my district, hosted a webinar to share what I was doing with other teachers nationwide, and contributed to many user blogs. Although I have intimate knowledge and believe in the potential of DreamBox, as a researcher, I have suspended that value judgement in conducting this research.

Summary

Because the 21st century classroom is evolving with the influx of technologies, this study seeks to contribute to the practices of teachers using technology, specifically, AMT. The teachers getting the most average student growth with the AMT, DreamBox, can help shed light on what this integration may look like with AMT. The following review of the literature includes the history of technology in the elementary classroom, studies with technology use in elementary math instruction, teacher practices in math instruction, game-based learning, digital game-based learning, adaptive math technology, as well as the theoretical framework for technology integration with which this study embraces as foundational to understanding the teacher practices of power users with AMT that emerge. The findings of this study have the potential to shape future professional development for teachers with AMT and highlight a more collaborative relationship between the technology and the curriculum used. Professional development may serve as "driver's education" for this amalgamating endeavor.

Chapter 2
Literature Review

With many school districts embracing the integration of technology, teachers have become facilitators in student learning as learning has become collaborative, student-centered, student-directed, and highly engaging (Greaves et al, 2012). With the increase of technology, teachers must decide what pedagogical practices are necessary for the logistics of physical integration, such as how to use the technology, how to model its use, and how to best scaffold students’ user skills and understanding of the tools needed. Teachers must decide the best practices for supporting technologies and incorporating them into the curriculum, and other practices needed to increase student outcomes.

AMT is widely used in elementary schools as a supplement to classroom curriculum. Although these math programs are not part of a standard curriculum, they must be addressed as a part of classroom resources. AMT has evolved in recent years with the most advanced programs being game-based and highly interactive. Since they are relatively new on the educational scene, best practices need to be established for teachers to successfully integrate and use these programs in the classroom. These practices should foster student growth and improve student outcomes. AMT and its classroom use is the focus of the present study. The following literature review serves to establish the research base describing computer programs in the classroom, computer programs and math instruction, teacher practices in mathematics, adaptive math technology, game-based learning and DGBL, factors for effective use of DGBL, and teacher involvement with DGBL.

Computer Programs in the Classroom

In educational settings, the technological era was ushered in as early as the 1970s, when computer programs began to be used in the classroom (Parker et al., 2014). One of the early forays into educational technology in the classroom were the PLATO terminals that were donated to around 150 of the 109,000 schools operating in 1975 (Parker et al, 2014). It wasn't until the "Video Disc" was introduced and the Apple personal computer was made available in 1977, that the number of computers employed in the classroom increased (Parker et al, 2014). As personal computers entered the market, initially only a few school districts were lucky enough to afford this cost prohibitive educational tool. Experts mark the entrance of computers into education at two points. In 1983, most schools had computers for general use and limited student use. This date is acknowledged as the first school-based computer use. The second recognized timeframe is circa 1991, the beginning of student-based computer use in schools. This was the time when most students had some access to personal computers (Parker et al., 2014).

Along with computer access in schools, came programs designed to teach, supplement lessons, and reinforce learning. Publications began to target teachers and administrators. Computers were being used to prepare students for future jobs in technology, provide an interactive learning tool, and increase the productivity of teaching and learning (Parker et al., 2014). Integration of educational technology had begun.

Digital Natives

With the increasing amount of technology available to schools, education has evolved in recent decades. The traditional model, a teacher lectures to impart knowledge and a student listens to receive that knowledge, is no longer the norm. This is especially true in a 21st century classroom. Prensky (2001) referred to children born after 1980 as "digital natives". This generation has grown up surrounded by technology used in an authentic way and integrated into their daily lives. In an age filled with smart phones, digital music, video games, computers, and other advances, students are inundated with information at their fingertips and highly engaging digital resources. Many school districts have embraced the integration of technology, thus signaling teachers to explore relevant ways to leverage its constantly evolving functionality to transcend their classrooms into student-centered, student-directed, collaborative, and highly engaging learning environments (Greaves et al, 2012). Certainly, the evolution of pedagogical decision-making involving technology integration and facilitation looks different across content areas. Math instruction, specifically in the elementary grades, has shifted over time due to the influence and development of computer program technology.

Computer Programs and Math Instruction

With the dawn of the 21st century, elementary mathematics has seen many advances as a result of the development and integration of computer programs. Specifically, the purely direct instruction approach that once characterized math pedagogy has transformed into a more student-centered and personalized form of instruction, which rejects rote procedural skills and encourages a focus on deep conceptual understanding. Technology has influenced this transformation by serving as a conduit through which concepts move from concrete to abstract (Guerrero, 2010). Integral in this addition of technology to math is the teacher's knowledge and ability to choose and integrate the most effective tool for the mathematical content being learned within the context of the educational environment as a whole (Porras-Hernandez et al., 2013). Teachers of mathematics vary profoundly on their efficacy with math technology. Web-based computer programs abound, and it's sometime left to the teacher to weed through the options and make decisions on the most appropriate fit to supplement their classroom instruction. A math teacher's attitude toward technology and their knowledge of how to integrate the math software into the curriculum, are factors that influence successful use (Li et al, 2016). Li et al (2016) studied early adopters, adopters, and non-adopters of technology and found non-adopters of game-based technology were more likely to have more teaching experience (thus be older) than early adopters or adopters. In addition, these same researchers found math teachers who played video games themselves and had higher level of efficacy with technology and were more likely to be early adopter or adopters of using computer programs to supplement their instruction (Li et al, 2016).

Elementary Instruction

Elementary instruction through its evolution was primarily teacher focused (Cuban, 2001). The teacher was the wise sage imparting knowledge on students. Students received that knowledge (or struggled with it) and regurgitated it back to the instructor in multiple ways (Aydin, 2005). This began to change when the educational focus of our nation shifted in the late 1950s. With the realization of the scientific progress associated with the Soviet Union's successful launch of the first satellite into space, the Department of Education turned its focus and mission to advancing math education (Dick, 1987). The following decades saw an evolution in how mathematics was taught, with an emphasis on personalized education. Researchers such as Glaser (1984), who introduced individually prescribed instruction (IPI), and Keller (1968) who advocated for a personalized system of instruction (PSI), focused on the student as the center of learning and personalized instruction designed for that student (Aydin, 2005).

Student Centered Learning

Student-centered learning (SCL) seeks to empower students to be at the center of their own learning. With the student as the focus of the instruction, there is a mutual respect between students and the teacher. The students can feel a sense of autonomy, have an increased sense of responsibility and accountability, and are active participants in their learning (Lea et al., 2003). Lea et al. (2003) identified these as key tenets of student-centered learning.

In addition to the above-mentioned aspects of SCL, this approach to learning provides students with a deep understanding and connection to concepts through the internalizing of learning (Lea et al., 2003). Students seek assistance from teachers when more strategies are needed. The teacher acts as a facilitator for exploring concepts and obtaining skills. This is what Lea et al (2003) refers to as *teacher and learner independence*. The interactions of the SCL classroom are built on mutual respect which allows students to learn from each other and contains a component of reflection (Lea et al., 2003).

Computer Assisted Learning (CAI)

With the invention of the personal computer, student centered learning garnered more attention as students engaged individually with a variety of programs for skill and drill of math knowledge. Still a supplement to classroom instruction, these programs were the beginning of students accepting greater responsibility for their learning. Technology known as computer assisted instruction was introduced. This technology initially focused on drill and practice. The computer provided the course content through tutorials and simulations (Aydin, 2005). Types of CAI for math include “drill and practice”, tutorial, simulation, and gaming (Aydin, 2005). Gaming programs contain the added component of competition where students can work to accomplish a goal individually or as a team with other students (Aydin, 2005). In early studies, CAI games were found to have a significant positive effect on learning (Liao, 2007; Christmann et al., 2003).

Teaching Practices in Elementary Mathematics

With so many ways to use technology, it is essential to study the teaching practices that make a difference in learning outcomes specific to the subject of mathematics. As stated previously, elementary math instruction has been greatly enhanced by the addition of computers in the classroom (Li et al., 2016). The National Council for Teachers of Mathematics' (2015) position on using technology for mathematics education is

> Strategic use of technology in the teaching and learning of mathematics is the use of digital and physical tools by students and teachers in thoughtfully designed ways and at carefully determined times so that the capabilities of the technology enhance how students and educators learn, experience, communicate, and do mathematics. Technology must be used in this way in all classrooms to support all students' learning of mathematical concepts and procedures, including those that students eventually employ without the aid of technology. Strategic uses support effective teaching practices and are consistent with research in teaching and learning. (p. 1)

The NCTM position goes on to state the importance of keeping mathematics learning at the center of teaching practices with technology playing an integrated but supporting role (National Council of Teachers of Mathematics, 2015). The national organization also publishes standards and processes for mathematics instruction. Integrating technology into the math classroom with authentic applications supports inquiry, reasoning, and collaboration, three of the processes shown to be effective in increasing student achievement in instructional programs (Koh, 2019; National Council of Teachers of Mathematics, 2015). Technology supports and provides authentic applications in mathematics, aiding students' learning of larger, overarching concepts and providing a venue for engaging in mathematics at high cognitive levels (Koh, 2019).

Researchers, in the quest to connect research with teaching practices, have been studying technology integration and how to combine best practices in math instruction with the multiplicity of functions technology provides. One model designed to assist in understanding of technology integration is the Technological Pedagogical Content Knowledge (TPACK) framework (Koehler et al., 2005; Mishra et al., 2006).

Theoretical Framework

The theoretical framework for this study is the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). TPACK acknowledges Shulman's (1986) Pedagogical Content Knowledge (PCK) framework which contended teacher's understanding of pedagogy and content area knowledge are interrelated with both being important for effective instruction and adds that technological knowledge is also an important part of that instruction.

The elements of TPACK framework are shown in Figure 1. The first element within the TPACK framework is pedagogical knowledge (PK). This is the teacher's knowledge of teaching methods and practices such as lesson design, classroom management, assessment, and feedback (Mishra et. al, 2006). This also includes teacher knowledge of best practices.

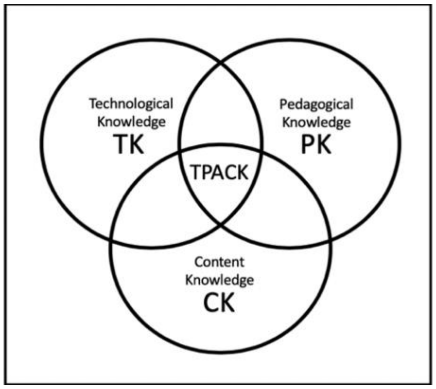

Figure 1. The TPACK Framework

The next aspect included in this theoretical framework is content knowledge (CK). Content knowledge is the instructor's knowledge of the specific information being taught such as geometry, surface tension, etc. Where pedagogy and content knowledge intersect is referred to as Pedagogical Content Knowledge (PCK). This is content knowledge specific to teaching a particular subject or specific teaching methods within the content area (Bower, 2017), such as using demonstrations to help students understand the physical science underlying the phenomenon of surface tension.

The final element is the educator knowledge of technologies (TK) available in the classroom. These technologies include web-based programs, interactive whiteboard knowledge, knowledge of mobile apps and their functions, virtual realities, augmented realities, and adaptive technologies (Mishra et al., 2006).

In addition to the above elements of the TPACK framework, some scholars have pointed out that context is an important aspect of the framework as well (Rosenberg et al., 2015). The TPACK framework must be considered within the context of the subject matter, grade level, type of classroom, and the technology available (Mishra et al., 2006). Context is an area some researchers feel is less developed (Rosenberg et al., 2015) but is important in this study. Understanding the subject matter, the type of technology (AMT) as well as the grade level, and teacher knowledge of students, is an aspect of understanding integration.

The 21st Century classroom seamlessly incorporates technology as an important part of the learning environment. The TPACK framework situates technological pedagogy as one of the three aspects of effective instruction and additionally incorporates an understanding of the student-directedness inherent in many facets of that prong. TPACK is not static or fixed, but a "dynamic and flexible body of knowledge influenced by both rapid changes in technology and the bidirectional relationship between knowledge and practice" (Mouza et al., 2014, p. 208).

Each element of the theoretical framework is interrelated with the other two elements. In essence, TPACK is a framework for the synergistic integration of technology, pedagogy, and content, in context, for the purposes of learning design (Angeli & Valanides, 2009). Bower (2017) states, "It highlights the interconnected nature of key dimensions of technology-enhanced learning, and in doing so provides a useful means for analyzing and self-reflecting upon teacher knowledge and practice" (p. 23).

Drawing on the theoretical framework of teachers' knowledge for technology integration, Technological Pedagogical Content Knowledge (TPACK), Koh (2019) describes what this framework means for mathematics. Technical pedagogical mathematical knowledge (TPMK) is what teachers use when crafting technology-integrated math lessons that have high cognitive engagement, are inquiry based, and help the learner use math reasoning in an authentic way to solve complex problems (Koh, 2018; Lingguo et al., 2010; Lim et al., 2016). Koh (2019) accepts the TPACK framework as providing "theoretical vocabulary to understand the different kinds of pedagogical considerations involved" (p. 1209). A unique and developing construct within the TPACK framework, TPMK emphasizes teacher focus on *mathematical* content when choosing technology tools to best contribute to the targeted conceptual knowledge (Koh, 2019).

Math teachers looking for ways to increase access, outcomes, and engagement, have explored online web-based math resources to supplement the curriculum, provide homework help, and video games for learning specific skills (Hollands et al., 2018). Digital tools providing feedback that clears up misconceptions or explains problem solving strategies are preferable but sometimes hard to identify (Hollands et al., 2018). The confluence of the teacher's technological knowledge and pedagogical knowledge is an important driver in what resources are chosen.

Adaptive Math Technology

Adaptive math technology is a math technology that is continually assessing a student's conceptual knowledge and math skills and providing continued instruction to review, teach, or enrich that knowledge and skill (Peng et al., 2019). It is the epitome of student-centered, personalized learning. This technology puts the student at the center of learning where the student shoulders the responsibility for interacting with the program and progressing in concept knowledge (Lea et al., 2003). Personalized learning is not a new practice. Confucius believed we should "teach children according to their aptitude" (Ma, 2015). Educational thought at the beginning of the last century postulated effective pedagogy was accomplished by allowing students to discover relationships from their personal experiences (Herbart, 1901). Both statements keep the student and their unique needs at the center of learning. With the goal of adaptive learning in math being to strengthen and expand conceptual knowledge, this venue seeks to focus on student data to steer instruction, adapting to the needs of the user (Peng et al., 2019). The goal of an educator is to provide meaningful, engaging instruction to the student in a way the student can understand, internalize, and ultimately integrate into their growing base of conceptual knowledge. In this way, adaptive math technology and the teacher both share the same goal, both constantly making adjustments in instruction to fit the needs of the student.

Adaptive math technology (AMT) was created to be tailored to individual students, constantly assessing their skill ability and designing lessons to fit their needs. Many early AMT programs were designed as a supplemental resource to classroom math curriculum for practicing basic math facts with drill-and-practice (Slavin, 2007; Rogosta, 1983).

An early form of adaptive math technology was a program produced by SuccessMaker in the 1980s, developed by CCC which stood for Computer Curriculum Corporation. CCC programs were designed to be used three to five times a week in 10- to 20-minute sessions. While this program assessed students' skills and knowledge in math and chartered a course to fill in missing concepts or expose them to new learning, it was not game based (Slavin, 2007). *SuccessMaker's Math Concepts and Skills* (a CCC program) was found to have positive effects on elementary students' computational skills but no significance in increasing conceptual knowledge or application (Rogosta, 1983). Although CCC programs were adaptive, they were based on a student completing computation or operations with drill-and-practice (Rogosta, 1983). This program moved each student along based on assessment of the student's own rate of learning and computational needs (Rogosta, 1983).

In the 1990s another adaptive math technology was created by Renaissance Learning called *Accelerated Math*. Marketed as computer-managed learning system (CMLS), it was meant to be a supplemental program to classroom instruction (Renaissance Learning, 1998). By scanning completed assignments into a computer system, teachers were provided diagnostic reports to provide a more targeted intervention to their students. This program focused on computational skills and assessment of student knowledge. In a large, randomized, quasi-experimental evaluation study, Ysseldyke and Bolt (2007) found no difference in the 2nd through 5th grade students' test score who had been assigned to the group using *Accelerated Math* as a supplement to their math curriculum.

Slavin et al (2007) found most studies showed some positive effect of CMLS but were not significant in conceptual knowledge or application. They did, however, conclude some studies showed a significant positive effect in computational skills. AMT has the unique ability to access student skills and provide them with individualized practice, which the researchers stated was the greatest advantage of this kind of computer learning (Slavin et al, 2007). While there were many early forms of AMT on the market throughout the 1990s and early 2000s, some were found to have benefits to student computational skills (Slavin, 2007).

Game-based Learning

Games by their very nature can deliver high quality learning opportunities (Gee, 2005). Engagers in game play often use problem solving, reasoning, and collaboration to reach a goal or triumph over another player (Gee, 2005). Video games are no different. Designers of games understand the principle of Darwinism. A high-quality game, that is able to be learned quickly and mastered at a certain level, will be played by a massive number of people, and will sell. If not, the game and the designer will not survive (Gee, 2003). Often long, complicated, complex video games are highly motivating. Gee (2005) believes “it is something about how games are designed to trigger learning that makes them so deeply motivating.” Looking at gaming in the realm of education by early pioneers such as Baltra (1990), added the concept of deep learning and understanding though gaming.

The Federation of American Scientists (2005), during the National Summit on Educational Games in 2005, gave digital games for education praise for the skills and concepts they can teach, most notably, strategic thinking, analytical thinking, decision making, problem solving, and adaption to change. These skills are vital to the world students are growing into (Spires, 2015). Principles of learning are intrinsically woven into playing and completing video games. Video games used for learning mathematical concepts are no different.

Digital Game-based Learning

In the early 1990s a new style of adaptive math technology entered the educational arena. Programs that used a more game-like environment in teaching mathematical concepts began to emerge. Gee (2005) concluded high quality games by nature teach players skills and knowledge needed to succeed in and complete (or win) the game. Games focused on student-centered learning increase engagement and a sense of independence (Motschnig-Pitrik et al., 2002) as well as responsibility (Urdan et al., 2006). Digital game-based learning combines the engagement of technology and the motivating nature of games to increase student learning and deliver positive outcomes (Gee, 2005).

Digital Game-based learning seeks to combine SCL with the principles of the intrinsically motiving learning that games provide. In a recent study by Coleman et al (2020), the researchers compared a conceptual linkage between SCL and DGBL drawing on the principles Gee (2005) established in earlier studies concerning video games and learning. For the purpose of this paper, active learning, a concept in both video gaming and SCL, is relevant to supporting students in DGBL.

Active learning involves the learner making choices with a degree of autonomy (Coleman et al., 2020). Decision-making by an individual is inherently active and requires the learner to engage with materials, concepts, and their own experiences to arrive at a conclusion (Coleman et al., 2020; Gee, 2005). This, according to Gee (2005) is part of the principle of co-design. Video games require the player to make consistent judgements on what is happening and what the next move should be, keeping in mind the end game (how to win the game). The interactive nature of video games requires active participation throughout, with the longer more complicated games requiring the player to make decisions, challenging them to plan ahead and deliberate consequences ahead. Consequences are sometimes immediate and sometimes far-reaching. The idea is the same in gaming as in SCL: the learner must be an active participant in their own learning (Lea et al., 2003; Gee, 2005; Coleman et al., 2020).

Coleman et al., 2020, compares Gee's (2005) principle of manipulation within a video game with active learning. Learning through action requires the learner to process the information in a given situation and manipulate the environment to achieve an incremental step or larger move toward a goal. This manipulation is essential for progression. Making decisions and discovering throughout a game is part of active learning (Coleman et al., 2020).

The principle of sandbox learning is sometimes applied to DGBL. When children play in a sandbox it is a safe and realistic but is a controlled venue to explore, play, and learn authentically (Gee, 2005). Many video games have an area a player can start out in to learn how the game works. Many times, this metaphorical sandbox is the place where learning starts without the pressure or consequences of a misstep in the actual game (Gee, 2005). 'Horizontal learning' is sometimes needed where students can play around, take risks, hypothesize, and explore in an innocuous way (Goto, 2002). They are afforded the time to learn, protected from consequences before moving up the vertical learning ladder (Goto, 2002).

As with SCL, it is important in DGBL for the student to see a bigger picture of how the concepts or skills fit into a larger system as a whole. This is sometimes referred to as system thinking (Gee, 2005). Learning is enhanced through system thinking. This aspect is essential to SCL. Coleman et al (2019) explains within this system thinking, SCL incorporates problem-based learning to which requires the application of what has been learn. Situating this new concept in the larger meaningful whole.

DGBL incorporates all of the principles and relationships discussed. The student starts out with the autonomy to make decisions about the direction of learning. The teacher is faciliatory in this endeavor and the student is responsible and accountable for their progress and effort. Through manipulation of the game elements, a learner starts in the sandbox and through authentic exploration, eventually moves onto learning concepts through playing the games. All of this requires system thinking, a necessary grasp of what the larger learning picture looks like (Coleman et al., 2020).

DGBL using adaptive technology

Digital game-based learning increasingly relies on the large amount data produced by adaptive technology programs, especially in mathematics, to assess student learning (Peng et al., 2019). Some AMT software producers combine the aforementioned learning principles employed in DGBL and the student-centered adaptive technology to increase outcomes (Peng et al., 2019). These programs provide immediate feedback for students and require mastery of game skills before advancing (Nguyen et al., 2006). They adapt to the student's concept knowledge and abilities. Through game play, the student completes tasks and makes connections. Cheung and Slavin (2013) found game-like adaptive math programs, sometimes called intelligent adaptive learning, had a positive effect on student learning. These programs are continuously assessing the student's mathematical needs and adapting the content to meet those needs (Retalis & Papasalouros, 2005). Most game-like adaptive math programs are student-centered, student-driven, and are sometimes used in isolation from the curriculum and even apart from any teacher intervention (Smith, 2018). The primary purpose of adaptive learning systems is to afford meaningful and personalized learning and feedback that can accommodate a multiplicity of student personalization free of teacher involvement (Luft et al, 2013).

Factors for Effective Use of AMT

Many factors affect the successful use of AMT in the classroom. Among the factors documented in the literature are access, engagement, and outcomes. However, teacher’s practices with access and engagement with AMT is scarcely addressed in the literature, although considered an essential factor in collaboration and facilitation of the technology (Peng et al., 2019; Prensky, 2001). Teachers’ needs and desires for PD from the developers of the adaptive math technology are evident (Callaghan et al., 2018). However, successful professional development from the producers of the technology may be limited when factors such as access and accountability measures are dependent on districts, schools, teachers, and resources available. Effective use of adaptive math programs requires seeing access, engagement, and outcomes as strands twisted tightly together, interdependent on one another, and stronger as a whole; leveraging the union to facilitate the greatest outcomes possible for students (Prensky, 2001; Gee, 2005). Students who have greater access to AMT and are actively engaged in game-based learning see better outcomes for their work which encourages further engagement (Gee, 2005).

Access

The US Department of Education (2017), in a recent publication, stressed the importance of bringing equity to learning. Guiding principles have been established by US Department of Education for the use of technology for elementary students. Principle #2 states, “Technology should be used to increase access to learning opportunities for all children.” (US Department of Education, 2017, p. 13). Acknowledging adaptive digital platforms offer flexibility and a personalized learning venue, access for all is essential.

Ertmer et al. (2012) determined that barriers to technology in the classroom were either *first order* (external to the teacher) or *second order* (internal to the teacher) barriers. First order barriers include resources (hardware and software), support (administrative and technical), and training. Second order barriers include confidence, beliefs and perceived value (Ertmer, et al 2012). Access to effective use of adaptive math technology in the classroom requires first order and second order barriers to be overcome. Classroom technology is dependent on the school district providing high quality hardware and access to the DGBL program for every student. In addition, training should be provided for teachers on the platform as well as easily accessible technical support from the provider and ongoing user support within the school or from the district (Callaghan et al., 2018).

Another access-related factor is teacher self-efficacy with the program, a factor which fits as a second order barrier. Wood et al (1989) described self-efficacy as the “beliefs in one's capabilities to mobilize the motivation, cognitive resources, and courses of action needed to meet given situational demands” (p. 408). Teachers who have put forth effort and had positive experiences with technology will be more likely to in turn see a new technology in a positive light therefore be willing to embrace the challenge it takes to learn it (Wood et al., 1989). Breaking free of this barrier and embracing the integration of DGBL will contribute to greater access for students as the program is integrated into the curriculum.

One feature of adaptive learning technology is its accessibility, providing DGBL anywhere at any time, creating a flexible learning setting (Peng et al., 2019; DreamBox Learning, 2014). With a username and password, access to the internet, and a device, a learner can play games limitlessly.

Engagement

Gee (2005) described the intrinsic nature of games. Video games are biologically motivating to learn and have the potential for high levels of engagement (Gee, 2005). Educational games are designed to make the learner feel empowered when they can manipulate characters, tools, or the game environment. A player seeks to increase their knowledge by interacting with the game, which will lead to feelings of accomplishment and power (Gee, 2005). This engaging aspect of gaming leads students to keep playing and learning from active experiences (Gee, 2005).

Engagement can also be seen in the collaborative nature of games. Sharing strategies and ideas with other students leads to a sense of team. Gee (2005) discusses the idea of co-design. Within a video game, learners see how their actions contribute to driving the game and creating a trajectory toward a path. DGBL is no different in its collaborative potential. When students share ideas and knowledge related to elements of the games with each other, this leads to social engagement and group connection. This form of engagement reinforces the desire to continue to play.

One study found children playing an adaptive digital literacy game had high levels of engagement at first, but the engagement decreased with time (Ronimus et al, 2014). The game used in the study, Graphogame, is “an adaptive serious game designed to prevent reading difficulties through the promotion of sound–symbol connections” (McTugie et al., 2019). Although not an adaptive math game, this adaptive reading game hosts some of the same characteristics. DGBL is naturally engaging as with other forms of gaming (Gee, 2005) but may need teacher involvement to continue to find a similar level of engagement throughout.

Outcomes

Lester et al (2014) found DGBL increased problem-solving abilities in math and science across all elementary grades. In addition, the iterative approach many adaptive game-based learning programs use supports content learning and has great potential for STEM content areas (Lester et al., 2014).

Problem solving ability was again found to be significantly improved after gameplay (Shute et al., 2015). Additionally, Shute et al (2015) found students all showed significant improvement in spatial skill and persistence. Along with the positive impact video games have on cognitive skills, the link to improving students' persistence in completing a task is important. The National Council of Teachers of Mathematics (NCTM) endorses the Common Core State Standards for Mathematical Practice. Standard 1 is "make sense of problems and persevere in solving them" (CCSSI, 2020). Game-based learning contributes to the perseverance in solving problems (Shute et al., 2015).

In a meta-analysis by Byun et al (2018), the researchers looked at how effective DGBL is with improving student outcomes. To calculate the overall effect size, this study looked at 17 studies involving the use of DGBL programs. The Cohen *d* was found to be 0.37 overall, this indicates a moderate effect (Byun et al., 2018). This group of researchers also acknowledged the DGBL studies individually "showed statistically positive effects on students' learning mathematics" (Byun et al., 2018, p. 121). Research on DGBL has increased recently, however, very few studies endeavor to look at their effectiveness empirically (Byun et al., 2018). The same researchers noted a lack of research by authors with a background in mathematics education. Researchers with an elementary mathematics teaching background could lend a nuanced perspective to other significant factors with implementing DGBL.

Teacher Involvement with DGBL

Teachers' understanding of pedagogy with adaptive math technology can be manifested in teaching practices or behaviors when integrating and implementing the various programs. Callaghan et al. (2018) identified eleven teacher practices found to be used with a game-based, adaptive math program. As explained below, the behaviors, used with varying frequencies are: viewing class reports, checking on students with issues, managing classes, re-training students on password, reordering objectives, test driving games, viewing response to intervention reports, accessing classroom resources, accessing manuals and guides, using whiteboard mode, and viewing professional development videos. DGBL programs vary somewhat on what the teacher can do and see on the dashboard, although the following elements on a DGBL dashboard are common.

Viewing Class Reports

The dashboard on most DGBL platforms gives a wealth of information and data for the teacher to view. Data for the class as a whole is expressed as average number of lessons, average time spent on lessons (during school hours and outside of school hours), and average class growth. These elements on the dashboard are also represented visually with graphs and charts.

Additionally, a teacher can access individual student data. This includes number of lessons completed, average time spent on lessons (inside/outside of school hours), overall growth within the program, progress made toward completing each standard, number of standards met, as well as what grade level each standard is on. By adjusting the timeframe, the teacher is accessing, a snapshot of progress can be viewed.

Some programs incorporate state standards and common core state standards with some more advanced programs including predictors for yearly state assessments based on student progress. Student progress in each standard is viewable.

Checking on Students with Issues

Another dashboard feature is an indictor when a student is struggling with a concept. The standard the student is working on in the game is highlighted for the teacher. This gives the teacher and opportunity to seeing what concepts are missing or misunderstood for the student. How a teacher handles this situation varies.

Reordering Objectives

The DGBL program follows algorithms to provide instruction personalized to each student. A teacher can manually remove or assign a lesson, essentially overriding the program. One reason for overriding the program is to remove an objective a student is struggling with, maybe in favor of the teacher re-teaching a skill or concept. A teacher might assign an objective that reviews a standard from a previous grade to get the student ready to build on that concept. Additionally, an objective might be reassigned to a student for practice or to build confidence in a specific skill.

Demo Games

Teacher who use DGBL in their classrooms sometimes test drive the games the students are playing. This aids in understanding of how the game presents, teaches, or reinforces a math concept. This can be helpful if students are struggling with the logistics of the tools within the game or understanding of how the game works. This can expose the teacher to new ways to teach a concept adding to content knowledge as well as pedagogy.

Test driving a game on the whiteboard setting (using the classroom whiteboard to run the program) allows students to see the teacher model a specific game and its tools as well as motivates students to play the game themselves.

Viewing Response to Intervention Reports

Some school districts use the data the DGBL programs provide for Response to Intervention (RTI) students. RTI is a multi-tiered initiative to identify and support students with learning needs (Gorski, D., n.d.). These students must be progress-monitored as part of the RTI process. Teachers use the data DGBL program provide as documentation of progress (or lack of progress) for this group of students.

Accessing Manuals and Guides

Accessing manuals or guides on how to use the program is another identified teacher practice. These resources are instructional for game play, suggestions on how to use the provided data, how to move student in and out of game levels, and general help with the program.

Viewing Professional Development Videos

Some DGBL programs offer professional development with getting started, helping students, navigating the program, and other user features. These videos are to increase the teacher's ability to understand the program and its potential.

Integration of AMT

Callaghan et al. (2018) concluded integration of math computer games was associated with improved student achievement with two of the examined teacher practices. Reordering game objectives and viewing PD videos were positively statistically significant with higher student achievement scores on end of year exams (Callaghan et al., 2018). Additionally, Callaghan et al (2018) concluded teachers recognized the need for more PD with integration and implementation of the technology. Addressing how to operate the adaptive math technology (AMT) available to a teacher is important. Given the programs have been shown to be effective in increasing student conceptual understanding, teachers need have an understanding of how to interact with them with a pedagogical lens. Using what the teacher knows about how students learn, student engagement, and student motivation, the teacher can be the facilitator in the student-AMT relationship. The aforementioned teacher practices that have been researched to date are all part of what is known of successful implementation and use of DGBL.

Summary

More research is needed regarding success with DGBL. Teachers who have consistently obtained high overall average student growth with DGBL, can shed light on what practices they engage in with regularity. This study seeks to add to best practices to increase student outcomes with DGBL through examining more closely what the practices are of highly successful DGBL teachers and identifying additional practices not previously documented that contribute to better student outcomes.

Chapter 3
Methods

Effective and successful teacher interaction with AMT requires the educator to develop a dynamic pedagogy—understanding the interconnectivity of content knowledge, technology, and teaching (Mishra & Koehler, 2006; Foster, 2020). Of interest to this study is how highly effective teachers interact with the AMT they have in the classroom. The research questions this study seeks to answer are: (1) What practices do highly successful teachers enact when using adaptive math technology? and (1a) When teachers interact with the AMT, do they focus on the class as a whole or individual student? This chapter provides the method for data collection, the survey and its development, the study participants, ethical considerations, as well as the procedures for measures and data analysis.

Theoretical Framework

This study applies the TPACK framework, defined earlier, to better understand the need for this study and how teacher practices with AMT are part of a dynamic set of skills within this framework. In particular, this study investigates the relationship between pedagogical knowledge and content knowledge, while also understanding how to best integrate AMT (technological knowledge) into the classroom. TPACK is an appropriate framework for this study because, at its core, TPACK seeks to give structure and understanding to the synergy of the three types of knowledge within the context of AMT and mathematical learning.

Research Design

I use survey research design in this study (Johnson et al., 2017). I chose survey research design because the study is looking to measure practices of a specific population. This cross-sectional survey targets teacher practices associated with AMT and contains open-ended questions to give participants an opportunity to share a free response. This type of survey research gives the participant a venue to share their practices, in their own words, to contribute to an overall understanding of their experiences. Free response data is evaluated qualitatively to look for categories and then codes. Identifying any additional types of involvement practices a teacher engages in with the AMT adds to understanding.

One of the strengths of survey research is to assess the occurrence of beliefs, attitudes, and perceptions (Donsbach et al., 2008). Surveys can also ask participants about facts, such as teacher practices with a software or pedagogical actions when integrating technology into the classroom. In addition, survey research is cost effective. The population being surveyed completes the study using a link. Less costly than mixed-methods, survey research can often take less time as well (Maruyama et al., 2014).

Questionnaires can eliminate interviewer bias, especially those taken via internet (Maruyama et al., 2014). The interviewer's tone, demeanor, or even appearance can create bias. A survey administered using a link eliminates that possibility.

Another strength is external validity. External validity is strong with survey research due to the generalizability to the full population (Wolfgang et al., 2008).

Survey research is not without weaknesses. Although administering a survey via internet link does reduce bias it also increases the likelihood a potential participant will be suspicious of an unsolicited invitation (Maruyama et al., 2014). This makes the case for the link coming from the AMT program the teachers are using. Receiving the link from DreamBox reduces this issue and provides a motivation to participate. Another weakness of survey research is assessing causation (Donsbach et al., 2008). Especially with cross-sectional surveys, when all responses are gathered in a single point in time, causation is difficult to assess. This is more problematic when assessing the perceptions of teacher (Donsbach et al., 2008).

Data Collection Methods

The data was collected via an online teacher survey (Appendix A). The survey was administered through QuestionPro, provided by the University of Tennessee, Office of Information Technology. The survey contains items to investigate teacher practices with AMT as well as demographics of the participants.

Sampling Scheme

This study used non-randomized, criterion-based sampling (Onwuegbuzie et al., 2007) to target teachers who are identified as power users. These are teachers have obtained the most student growth within each AMT. Since the research objective was to explore what teacher practices are being employed by the power users of the programs, the focus was a sampling of teachers with the highest average class growth. Non-randomized sampling (targeting power users) gives insight into understanding teacher practices with AMT. This purposeful sampling is most likely to contain rich information about teacher influences in the adaptive math programs (Onwuegbuzie et al., 2007).

Participants

The participants in this study are elementary grades teachers (K-5) whose students use DreamBox in their classrooms and have high average student growth. The research survey targeted 8,000 power users identified by DreamBox as having the highest overall average student growth, in the grade level they teach (the top 10%), in the current school year. This means the surveyed teachers are the highest overall average student growth producers in their grade. A recruitment letter was created (see Appendix D) as well as a follow up letter (see Appendix E) to be distributed by DreamBox via email to their power users. A link to the survey was forwarded to the participants by DreamBox. The total number of completed surveys returned and used in this study is 117. Only those participants who completed the 32-question survey in its entirety, including the qualitative questions, were included. Those teachers who chose the "Prefer not to answer" option on any question but proceeded and completed the survey were included as well.

Student Growth in DreamBox

The student growth percentage is the percentage of standards the student has completed proficiently. This is a combination of standards completed in the student's grade level as well as any grade level above or below. Growth calculation starts over at the beginning of each school year.

For a student to reach proficiency in a standard, the student must successfully complete measurable learning objectives to show understanding. "The DreamBox curriculum designers program the learning engine to present students with a range of problem set sizes for each objective" (DreamBox Learning, 2012). In the same way a teacher may access a student's proficiency one on one, the program "analyzes how accurately and quickly students answer problems and then adjusts the number of problems they must solve to achieve proficiency" (DreamBox Learning, 2012). The number of problems vary from standard to standard and from student to student depending on the student's completion of game-like lessons. In this way, the adaptive features of the program personalize the learning environment for each student (DreamBox Learning, 2012).

To calculate the percent growth for an individual student, the program gives the percent of standards the student is proficient in. An example of this is a first grader working on Common Core State Standard 1.NBT.3 will need to be proficient on all 31 measurable learning objectives (DreamBox Learning, 2012). There are 21 math standards to be completed in first grade math within the CCSS. If a student has shown proficiency in 14 of the standards, the student's percent growth score will be 67%.

Ethical Considerations

Ethically, whenever a vulnerable population such as minors are involved in research, there must be safeguards in place to protect them as well as their personal information, privacy, and identifiable data. Using class data instead of individual student data protects student information and greatly reduce the possibility of student and data connection.

The participating teachers signed a Consent for Research Participation when agreeing to take the survey. As stated in the consent form adapted from the University of Tennessee IRB website, every attempt was made to keep the information in this study confidential. Data is stored securely in a folder on the researcher's hard drive and will only be made available to persons involved the study. No reference is made in oral or written reports which could directly link a participant to the study. When information from this study is published or presented at scientific meetings, no personal information will be used (University of Tennessee Institutional Review Board, 2018).

Measure

The survey instrument for this study was developed based both on previous teacher practices research (Callaghan et al., 2018) with AMT in the classroom and how the TPACK model describes teacher's practice with DGBL. The adoption and highly effective use of AMT in the classroom requires access to the technology, the teacher having an understanding of how the AMT works (technological knowledge), the teacher using pedagogical knowledge with the technology (technological pedagogical knowledge), the teacher using AMT to increase content knowledge, and the teacher using knowledge of content, pedagogy, and technology together

(TPACK) to increase the learning outcomes for all students. These areas were considered when creating the questions in the survey.

Access to the AMT

Questions two, four, and five ask the participant about student access. Student access involves the availability of a device (desktop computer, laptop computer, or tablet) to use the AMT. Additionally, a student needs internet access to be able to use the AMT at home or at school. Embedded in questions five is the assumption that if the student is accessing the program, they also have internet access. Within question six, the survey inquires about teacher access and how often they access the dashboard.

Teacher Technological Knowledge

Questions six through nine inquire about what practices the teacher engages in when viewing the AMT dashboard. What data does the teacher view for individual students and for the class as a whole? Also included within this question group is an opportunity for the power user to add a free response. This enriches the study with qualitative data and helps the researcher better understand the technological practices of the teacher.

The teacher's technological knowledge of the program can be gauged by what practices are used when accessing the dashboard. Checking lessons completed, student time on the program, student growth, standards completed by the student, and assigning and removing lessons, shows how the teacher uses technological knowledge of the program. Questions seven and eight ask what the teacher practices are with the individual students. Questions nine and ten ask about practice with regard to the whole class.

A teacher's use of the demo function also captures the teacher technological knowledge. The is addressed in questions twelve and thirteen. A teacher's ability to explore, navigate the game, and use the in-game tools requires a level of technological knowledge.

Teacher Technological Pedagogical Knowledge

Question twelve contains elements of the teacher's technological knowledge and pedagogical knowledge. It asks the reason or reasons for demoing a game. The teacher might demo a lesson to understand the technology to a greater degree or gain user knowledge to help a struggling student. This might include analyzing the game for math concepts or strategies needed. This falls between technological knowledge and technological pedagogical knowledge (TPK).

Question three also address the teacher's technological pedagogical knowledge. Pedagogical knowledge is the teacher's knowledge of methods of teaching (Lim et al, 2016). Based on the teacher's knowledge of how students learn and the methods and processes of instruction, the teacher practices with the AMT are questioned. Question three asks one of the most telling question regarding pedagogy. How are you currently using DreamBox? Answers to this question give insight into the pedagogy of using AMT in the classroom. Teachers use AMT for student review of current content, student review of content from prior grades, to teach new content, for enrichment, and for additional practice of current content. Question 16 contains an open-ended response opportunity for the power user to add any additional pedagogical practices.

Teacher Content Knowledge

Question 14 addresses teacher content knowledge and the degree to which playing a game has enhanced their content knowledge. Many of the game-based learning program present concept development in new and unique ways, show unique connections, and help visualize mathematical concepts (DreamBox Learning, 2014). Playing a game within the program may increase teacher content knowledge. This question asks if playing games (lessons) on DreamBox has enriched math content knowledge. It is followed up by question 14, an open-ended question giving the participant an opportunity to explain.

Teacher Technological Pedagogical Content Knowledge

Addressing teacher technological pedagogical content knowledge, question 17 asks to what extent involvement practices are used when a student has difficulty with a lesson. The question is assessing what practices a power user engages in. Helping a struggling student with the lesson many times requires math CK, PK, and TK to resolve. Based on these teacher's knowledges, the question inquires how the teacher helps the student. Questions 17 and 18 inquire about what practices a teacher uses if a student needs assistance with the AMT. Options for this question explore what practices power users engage in to help their students. Letting DreamBox adapt with scaffolding as it was designed to by reminding students to click the "Help" and "Hint" buttons as well as answer the question a few times and listen to the DreamBox feedback when they are incorrect, helping the student while they are in the lesson, have another student help the student struggling, assigning a supportive lesson, helping the student using a demo lesson, or letting the student struggle are all options. The participant can add an additional option via short answer (question 18). This involvement gives insight into the teacher's overall understanding of TPACK.

Demographics

Additionally, the survey contains demographic questions. These questions were used to ascertain the power user's grade levels, years of overall teaching experience, years of experience with DreamBox, as well as the type of school (rural, urban, charter, etc.).

Survey Validation

To achieve face validity as well as content validity, prior to DreamBox distributing the survey link to the participants, the constructed survey was given to seven experts in the field of math and/or game-based learning as well as teachers who have used DreamBox and would be considered power users. These experts and their specific qualifications are provided, below. Each validator was sent an expert recruitment email (Appendix B) asking if they would be willing to give feedback on the survey instrument to be used in this study. This is to ensure the survey contains all aspects of the construct to be measured and the questions indeed measure what they need to measure to answer the research question.

Survey Validators

Validator 1 has a PhD in Math Education and has worked extensively with AMT. This validator is currently a Math Curriculum Coordinator for a district in the southeast. Validator 1 was part of a team of experts and educators who researched, purchased, and implemented DreamBox and other AMT in her school system. As of May of 2020, the school system no longer uses DreamBox Learning as the AMT for the district.

Validator 2 has a PhD in Math Education and is currently a Clinical Assistant Professor, STEM and Math Education at the university level. This validator's qualitative research is in game-based learning with pre-service teachers.

Validator 3 is a 4Th grade Math Educator in the south eastern region of the United States. This validator has 17 years of teaching experience (K-8), certified as Highly Qualified and was a member of DreamBox Nation. DreamBox Nation recognizes the top 10% of users. Although this validator has five years of experience with DreamBox, Validator 3 no longer uses the program in the classroom.

Validator 4 is currently a 6th grade Math Teacher a middle school in the south eastern region of the United States. This validator has 21 years of teaching experience and five years of experience with DreamBox. As a second-grade teacher, validator 4 was consistently one of the top teachers in the school system, producing superior average student growth each year. Validator 4 was awarded “Teacher of the Year” in a recent school year and awarded The DreamBox Hero award. This honor is awarded to ten teachers from across the county who reflect DreamBox Learning’s core values and are at the top of their profession (Cross, 2016). Validator 4 is not a currently user of DreamBox.

Validator 5 has a Master of Science in Education and teaches in the south east region of the United States. Validator 5 has eight years of teaching experience and five years of using DreamBox in the classroom. Validator 5 has been recognized by DreamBox as a power user and by the district for her consistent high average student growth within the program. Validator 5 is not a current user of DreamBox.

Validator 6 is a Kindergarten teacher in the United States. This validator has 15 years of experience teaching and five years of experience using DreamBox. Validator 6 has consistently had the top average student growth with the program in the district. This validator is not a current user of DreamBox.

Validator 7 is a first-grade teacher with five years of high average student growth with DreamBox. Recognized as a power user, this validator is consistently producing superior growth and give support within the school and district to other DreamBox users.

Because the survey was sent to the participants via DreamBox Learning, they requested to have a copy of the survey for approval. DreamBox requested several changes due to a recent update in the functionalities of the dashboard and recent features that were added to the program.

This was to ensure all participants had the targeted information available on their dashboard as there are various levels of the program school systems can purchase. Appendix C shows the survey validators contribution to the instrument as well as the technical changes requested by DreamBox.

Data Analysis

After preparing the data by removing nonresponses and incomplete responses, to answer research question one, descriptive statistics were run on the collected data to find the mean as a measure of central tendency. Descriptive statistics were run for the following questions, (question 3) teacher uses for DreamBox, (question 7) practices with individual students, (question 9) practices with the class as a whole, (question 12) teacher uses of demo lessons, (question 17) practices for assisting struggling students, and (question 23) practices for motivating students to use DreamBox. The means and standard deviation were used to interpret the findings on the original scale of the survey to determine which practices are occurring most.

To address research question 1a specifically, a paired sample t-test was run using the overall means to see if there is statistical significance for questions seven (individual students) and nine (the class as a whole) to discover if teachers favor one more than another.

Additionally, descriptive statistics were run to determine the power user's age, years of teaching experience, grade levels, years of experience with DreamBox, as well as the school location, and type of school.

For question 11, the percentage of teachers who demo the games within the program was calculated to determine whether this is a practice of most power users.

The qualitative data in the study adds to the practices in which the teachers engage. This data shows the power users' current practices that influence average student growth within the program. I use descriptive coding (Saldana, 2011) to analyze three qualitative questions and established categories and then coded for teacher practices.

The data was first sorted into general categories, then narrowed down into codes, and the frequency for each code was calculated (Saldana, 2011). The codebook described each code and provided an example(s) to aid in understanding (see Appendix F). Ultimately, final codes were established to describe recurring practices described by the participants based on the frequencies of the codes. To add to the reliability of the data analysis, once codes were established by the primary researcher, two additional qualified raters analyzed the data independently and coded all responses using the established codebook. The interrater reliability for question 8 was 99.98% partial agreement, 80.8% full agreement (k = 0.858), while question 10 had 99.98% partial agreement, 76.3% full agreement (k = 0.817). All partial agreements were discussed, and consensus was reached regarding final codes. Some elementary specific terms were clarified as the two additional researchers have less experience in those grade levels.

Summary

This study investigated what teacher practices power users engage in with AMT. The AMT company, DreamBox, sent a survey, validated by experts in the field, to the top 10% of their users. These are teachers who have shown the most average student growth with DreamBox in the 2020-2021 school year.

The present study lends understanding to the teacher's role in AMT, a program sold to school systems as student-centered, student-driven; no teacher needed. The first step in this process is to identify those practices power users engage in when they take the steering wheel of this self-driving car. This study addresses the gap in the literature about the most effective teacher role with AMT.

Chapter 4
Findings

The purpose of this study was to examine the practices of highly successful teachers with AMT (DreamBox). As a result of surveying teachers who use DreamBox learning, this study describes the teacher practices that influence student growth. In addition, this study examines the level at which this group of teachers focus their interactions with AMT, individual or whole group.

The results of the demographic questions, as well as the quantitative and qualitative results, are described in the following sections. These results include descriptions of how teachers are currently using DreamBox, their practices with individual students, practices with class as a whole, teacher use of demo lessons, and the practices teachers engage in when a student has difficulty with a lesson. Analysis of open-ended questions is also included.

Participant Demographics

Data was collected via survey from 117 power users of DreamBox during the beginning of the second semester of the 2020-2021 school year. A link to the survey created in QuestionPro and validated by experts in math and/or adaptive math technology was sent to DreamBox, who in turn, sent, via email, a description of the study to their power users. The survey consisted of Likert scale and free response questions. Of the 8000 power users who received the survey link, 117 participants completed the 32-question survey in its entirety, including the qualitative questions subsequently coded by the researcher, although some of the included teachers did choose the "Prefer not to answer" option. The official response rate was 1.5%. However, 87 participants started but did not complete the survey in its entirety and were not included (total response rate was 2.6%). Participants self-reported their age, teaching experience, grade level, school location, and type of school. Table 1 summarizes the participants' demographics. Additionally, 71.81 % of teachers (n = 79) reported having used DreamBox for two years or less.

Quantitative Results for Research Question 1

This study sought to answer research question 1, what practices do highly successful teachers enact when using adaptive math technology. The study looked at how teachers use AMT in the classroom, both for individual students and the class as a whole, the use of demo lessons, assisting students when they struggle, and motivating students to use DreamBox. The following are the results of the descriptive statistics of the Likert-scale questions.

Uses for DreamBox

Teachers use DreamBox for a variety of reasons in the classroom. When asked how the teacher is currently using DreamBox, on a 4-point Likert scale, the most utilized practice is for student review of content from the current grade (M = 3.11). This practice is followed closely by teachers reporting they use the technology for additional practice of current content (M = 3.07). Table 2 shows the ways teachers are currently using DreamBox.

Practices with Individual Students

Teachers were surveyed on eleven practices with individual students. On a 4-point Likert scale from "never" to "always", the most common practices were viewing the total amount of time on the program (M = 3.34) and viewing lessons completed (M = 3.02). Additionally, teachers reported viewing standard completed (M = 2.88) and viewing student growth (M = 2.74). Removing or canceling assignments (M = 1.42) was the practice least used by power users. Table 3 shows the results for teacher practices with individual students on DreamBox.

Table 1

Teacher Demographics

Demographic Categories	Frequency	Percent
Age		
20-25	6	5.4
26-30	11	9.9
31-35	11	9.9
36-40	18	16.2
41-45	13	11.8
46-50	21	19
51-55	21	19
56+	9	8.1
Prefer not to answer	7	6.3
Years of Teaching Experience		
1-5	18	15.4
6-10	18	15.4
11-15	20	17.0
16-20	22	18.8
21-25	19	16.2
26-30	10	8.5
31+	6	5.1
Prefer not to answer	4	3.4
*Grade Level		
K	21	13.3
1	23	14.6
2	30	19.0
3	30	19.0
4	30	19.0
5	19	12.0
Other	5	3.2
School Location		
Rural	18	15.4
Urban	17	14.5
Suburban	73	62.4
Other	8	6.8
Prefer not to Answer	1	.9

Table 1 continued

Demographic Categories	Frequency	Percent
Type of School		
Public Non-charter	108	92.3
Public Charter	5	4.3
Private Religious	2	1.7
Private Non-religious	0	0
Other	1	.9
Prefer not to Answer	1	.9

*Note. N= 117. *N = 158 for Grade Level, a teacher may teach more than one grade level.*

Table 2

Current uses of DreamBox

Practice	Mean	Std. Deviation
For Student review of content from the current grade	3.11	.818
For additional practice of current content	3.07	.838
For enrichment	2.76	.925
For Student review of content from prior grades	2.75	1.033
To teach background material that the student did not previously learn.	2.74	1.060
To teach new content	2.03	.991

Note. N = 117. The only answer left off this list is "Other, please explain". No answers were given for that choice.

Table 3

Teacher Practices Regarding Individual Students

Practice	Mean	Std. Deviation
I view total amount of time on the program.	3.34	.756
I view lessons completed.	3.02	.982
I view standards completed.	2.88	.842
I view growth (Student Overview).	2.74	.882
I view the student's Activity Feed	2.47	.925
I look at student growth on long-term assignments.	2.21	1.005
I look at student performance on short-term assignments.	2.18	1.014
I make short-term assignments for an individual student.	2.05	.955
I make long-term assignments for an individual student.	2.02	.974
I use the student messaging feature to communicate with the student	1.44	.547
I remove/cancel assignments.	1.42	.660

Note. *N = 117.*

Practices with Whole Class

Power users were also surveyed about their practices regarding the class as a whole. On the same 4-point Likert scale as above, the only practice averaging “most of the time” or “always” was the viewing of completed lessons (*M* = 3.02), the total number of lessons completed in the school year by all students in the class combined. Viewing number of standards completed (*M* = 2.75) and what specific standards have been completed (*M* = 2.68) were the next most common practices, followed closely by viewing the activity feed (*M* = 2.61). For the class as a whole, as with the individual practices, the teachers reported the practice least engaged in was removing or canceling assignments (*M* = 1.43). Table 4 shows the results for teacher practices regarding the class as a whole.

Use of Demo Lessons

One question asked power users, “For what reason(s) do you demo a game in DreamBox?”. Of the teachers who answered this question, only 33.6% of teachers (N = 39) reported the use of demo lessons, while 66.4% report never playing a demo lesson (N = 77). One teacher preferred not to answer. Within the third of the teachers who do play demo lessons, the most common reason for this practice is to help a student with the user-interface (knowing how to use a virtual manipulative or game). In addition to helping a student with the user-interface, understanding how a tool works within a game is another highly reported practice of the teachers who play a demo lesson.

To refresh content knowledge or to learn new content knowledge, had low means on this question. When asked in a separate question if playing demo lessons has enhanced the teacher’s content knowledge, this aligned with neutral, trending slightly toward agree. Table 5 shows the means and standard deviations related to the reasons a teacher plays a demo lesson in DreamBox.

Table 4

Teacher Practice Regarding the Class as a Whole

Practice	Mean	Std. Deviation
I view lessons completed.	3.02	.991
I view total standards completed.	2.74	1.010
I view standards completed.	2.68	.962
I view the Activity Feed.	2.61	.982
I look at student performance on short-term assignments.	2.13	1.030
I make short-term assignments.	2.09	1.050
I look at student growth on long-term assignments.	2.05	.990
I make long-term assignments.	1.96	.977
I use the student messaging feature to communicate with students.	1.48	.738
I remove/cancel assignments.	1.43	.661
Other, please explain other practices below.	1.21	.676

Note. *N = 117*.

Table 5

Reasons to Play a Demo Lesson in DreamBox

Reason	Mean	Std. Deviation
To help a student with the user-interface (knowing how to use a virtual manipulative or game)	3.03	.811
To understand how the tools work within the game	3.00	.725
To help a student with conceptual understanding	2.44	.912
To learn strategies to play the game	2.44	.940
To help a student with procedural skills.	2.33	.869
To analyze the game for math concepts (to supplement current curriculum)	2.13	.978
To learn new strategies for presenting a concept	2.05	.944
To model math strategies in a game (whiteboard)	1.97	.986
To refresh content knowledge	1.95	1.025
To connect with students	1.82	.942
To learn new content knowledge	1.79	1.031
For enjoyment	1.38	.673

Note. *N = 39.*

Assisting Students

Another question asked what power users do when a student has difficulty with a DreamBox lesson. The most used form of assistance when a student has difficulty is to let DreamBox adapt with scaffolding as it was designed to by reminding students to click the “Help” and “Hint” (M = 3.02). Another reported common practice was to help the student with the lesson while they are in the lesson (M = 2.06). Helping the student with paper, a whiteboard, or a chalkboard, fell just below once in a while. Table 6 shows the results of the teacher practices when assisting struggling students.

Motivating students

The qualitative responses showed teachers use rewards and accountability to motive their students to use the program. Because this response showed up 57 times in the qualitative data, the related, Likert scale question was analyzed for descriptive statistics. This practice of motivating students to play the lessons, is shown in this study to be a practice of power users of DreamBox. Table 7 shows the results. In this case, the teachers were not asked to distinguish between whole class and individual practices. The most implemented practice is publicly acknowledging lessons completed and/or growth achieved (M = 2.61). This practice was also a code established from the qualitative data. The code, Rewards & Accountability, was found 20 times in practices with whole class data (Table 11) and 23 in the practices with individual student data (Table 10). Additionally, this code was found in 14 more responses when asked what other classroom practices the teachers engage in when using DreamBox (see Table 12) for a total of 57 times.

Table 6

Teacher Practices for Assisting Struggling Students

Teacher Practice	Mean	Std. Deviation
I let DreamBox adapt with scaffolding as it was designed to by reminding students to click the "Help" and "Hint"	3.02	.830
I help the student with the lesson while they are in the lesson.	2.06	.769
I use paper, a whiteboard, or chalkboard to help the student.	1.97	.819
I don't do anything.	1.64	.923
I assign a supportive DreamBox lesson.	1.60	.788
I help the student using a DreamBox demo lesson accessed through my teacher dashboard	1.51	.795
I have another student help the student with the lesson.	1.50	.837

Note. *N* =117. Means based on a 4-point Likert scale (never, once in a while, most of the time, always).

Table 7

Teacher Practices for Motivating Students to use DreamBox

Practice	Mean	Std. Deviation
I publicly acknowledge lessons completed and/or growth achieved (i.e., with a chart on the bulletin board or weekly email to the class.	2.61	1.238
I give a reward for lessons completed	2.28	1.231
I give a reward for growth in math concepts	1.81	1.008

Note. N = 117. Means based on a 4-point Likert scale (never, once in a while, most of the time, always).

Research Question 1a: Individual Versus Whole Class

Research question 1a asks if, when teachers interact with AMT, do they focus more on individual students or the class as a whole. Two types of teacher practices with DreamBox were analyzed. First, teachers were asked about their practices with regard to individual students. Second, teachers were also asked about their practices with regard to the class as a whole. This includes those practices teachers engage in when assessing whole class data or implementing strategies for all students as a unit. Understanding both aspects of teacher practices is important. To answer this question, a paired sample *t*-test was used to compare nine practices. The only practice with statistical significance ($p = .016$) was the teacher looking at student growth on long-term assignments. Teachers tend to look at individual student growth on long-term assignments ($M = 2.21$, $SD = 1.01$ more than whole class ($M = 2.05$, $SD = .99$). Table 4.8 shows the results of that paired *t*-test.

Qualitative Results for Teacher Practices with AMT

To gain a more complete understanding of the practices of highly effective teacher users of AMT, qualitative responses were analyzed using descriptive coding. The focus of this qualitative analysis was to describe the participants' practices using the open-ended responses gathered by the survey to help answer RQ 1. The data analysis technique used looked for keywords and phrases to identify patterns and frequencies in the responses (Lee et al, 2006). Responses that did not answer the question or address a practice were not considered for analysis. Table 9 lists the question and the number of responses. Some participants left this open-end question blank or answered "n/a".

Table 8

Individual vs Whole Class Teacher Practices

Pair	Individual	Class	Paired sample t-test			
	Mean	Mean	*t*	*df*	*p*	Effect size
I look at student growth on long-term assignments. *	2.21	2.05	2.46	116	0.016	0.23
I view standards completed.	2.88	2.74	1.72	116	0.088	0.16
I view the student's Activity Feed	2.47	2.61	-1.66	116	0.099	0.15
I make long-term assignments for an individual student.	2.02	1.96	1.09	116	0.276	0.10
I look at student performance on short-term assignments.	2.18	2.13	0.93	116	0.357	0.09
I use the student messaging feature to communicate with the student.	1.44	1.48	-0.82	116	0.413	0.08
I make short-term assignments for an individual student.	2.05	2.09	-0.65	116	0.517	0.06
I remove/cancel assignments.	1.42	1.43	-0.15	116	0.880	0.01
I view lesson completed	3.02	3.02	0.00	116	1.000	0.00

Note. $N=117$. $*p < .05$

Table 9

Qualitative Questions

Question	N
8. Please explain what classroom practices or routines you find most helpful and how those practices impact individual student progress in DreamBox	104
10. Please describe any other classroom practices or routines that you engage in with regards to the class as a whole	76
16. What other classroom practices do you engage in when using DreamBox?	37

Table 10

Teacher Practices with Individual Students Codebook

Codes	Frequency	Definition
Scheduled time	28	Teacher has intentional scheduled time for DreamBox; Daily DreamBox time
Rewards & accountability	23	Teacher gives a reward for lessons/time/standards completed. Teacher holds students accountable for their progress and achieving their goals.
Time/lesson requirement	21	Teacher has a set required time/number of lessons on DreamBox; Teacher sets goal for time or lessons completed
Fill in gaps & enrichment	19	Teacher assigns lessons from previous grades to fill in gaps; Teacher assigns lessons to fill in grade level gaps; Teacher assigns lessons for grades beyond.
Identify strugglers & help sessions	15	Teacher uses assignments/data to identify students struggling; Teacher schedules help sessions for DreamBox lessons. Teacher works with the student to help solve problems with a game.
Pairing with current content	11	Teacher pairs what she is teaching in class with the corresponding standard on DreamBox.

Additional Practices with Individual Students

For teacher AMT practices with regard to individual students, 117 completed surveys resulted in 104 responses to this question. Thirteen non-answers were removed due to participants leaving this open-end question blank or answering “n/a”. Six codes were established, with the same method being used for questions eight (individual practices), ten (whole class practices), and 16 (other additional practices), with varying frequencies for each. Table 10 shows the code, a definition of the code, and the frequency.

Additional Teacher Practices with Whole Class

For teacher practices with the class as a whole,117 completed surveys yielded 76 responses. Forty-one participants did not give a response. The remaining responses were analyzed, resulting in six codes with varying frequencies. These practices, frequencies, and a definition of each code is documented in Table 11.

Additional Teacher Practices with AMT

Teachers were asked an open-ended question regarding other classroom practices they engage in when using DreamBox. Those responses were analyzed, resulting in six codes with varying frequencies. Out of 117 completed surveys, 61 non-answers were eliminated, and 19 were not coded due to the participant not answering the question. An example of a participant not answering the question is, “Can’t think of any others” or “None, gotta run because I’m trying to do this on my lunch break”. No additional codes were generated. The remaining 37 responses were noted as additional input but did not generate any new codes. Table 12 shows the results of additional practices teachers used.

Table 11

Teacher Practices with Whole Class Codebook

Codes	Frequency	Definition
Rewards & accountability	20	Teacher gives a reward for lessons/time/standards completed. Teacher holds students accountable for their progress and achieving their goals.
Scheduled time	15	Teacher has intentional scheduled time for DreamBox; Daily DreamBox time
Time/lesson requirement	11	Teacher has a set required time/number of lessons; Teacher sets goal for time or lessons completed
Fill in gaps & enrichment	6	Teacher assigns lessons from previous grades to fill in gaps; Teacher assigns lessons to fill in grade level gaps; Teacher assigns lessons for grades beyond.
Grouping Students & peer coaching	5	Teacher uses data to group students; Teacher sets up student to student assistance.
Pairing with current content	4	Teacher pairs what she is teaching in class with the corresponding standard on DreamBox.

Table 12

Other Classroom Practices Using DreamBox Codebook

Codes	Frequency	Definition
Rewards & accountability	14	Teacher gives a reward for lessons/time/standards completed. Teacher holds students accountable for their progress and achieving their goals.
Identify strugglers & help sessions	10	Teacher uses assignments to identify students struggling; Teacher schedules help sessions for DreamBox lessons. Teacher works with the student to help solve problems with a game.
Pairing with current content	6	Teacher connects DB lesson with current content being taught. Teacher assigns whole class lessons based on current content.
Fill in gaps & enrichment	4	Teacher assigns lessons from previous grades to fill in gaps; Teacher assigns lessons to fill in grade level gaps; Teacher assigns lessons for grades beyond.
Time/lesson requirement	2	Teacher has a time or lesson expectation for the class.
Scheduled time	1	Teacher has intentional scheduled time for DreamBox; Daily DreamBox time

Summary

The purpose of this study was to identify the practices of highly effective AMT users. Through analysis of the survey data from 117 power users, this study has recognized practices these users engage in most often. Highly successful teachers use AMT for review of content from the current grade and for additional practice of current content. While teachers look most often for the amount of time students spend on DreamBox and the number of lessons completed on an individual student level, they most often look at the total number of lessons completed on a whole class level. When a teacher plays a demo lesson it is most often to help a student with the user-interface or to understand how a tool works in a game. When a student has difficulty with a lesson, highly successful teachers let DreamBox adapt with scaffolding. And lastly, to motivate students to use the program, teachers most often give rewards to students in the form of public praise or acknowledgment and have accountability systems in place.

The study also looked at whether this group of power users focused their use of AMT more on individual students or the class as a whole. While no statistical significance was found to support a difference in teacher behaviors related to individual versus whole class focus, teachers did view student growth on long-term assignments more often for individual students over whole class ($p = .016$).

Chapter 5
Discussion and Implications

This study attempt to answer the questions of what practices do highly successful teachers enact when using adaptive math technology and when teachers interact with the AMT, do they focus on the class as a whole or individual student? This study examined the practices of teachers who obtain the most growth in the AMT, DreamBox, specifically seeking to answer the questions: Understanding what practices highly effective teachers engage in most with AMT can lead to a better understanding of how to effectively use this technology to support higher outcomes for all students. This study identifies specific practices the participants report using on a daily basis. In addition, this study finds teachers most often engage in the TPK component of TPACK, that is, they take what they know about how students learn and their knowledge of the technology and use the AMT in a collaborative way with the curriculum, each part supporting and enriching the other within the context of the educational setting. In each identified practice, components of the TPACK model can be seen.

Discussion

Because AMT is sold to school systems as student-driven and independent from the daily lessons taught or the overall curriculum map teachers use to plan instruction, many teachers may miss the opportunity to truly integrate this technology into instruction. This study builds on several research-based assertions: Digital game-based learning uses a game-like environment to access and increase student concept knowledge in math (Peng et al., 2019; Cheung et al., 2013), AMT is a form of DGBL that is effective in increasing math achievement (Gee, 2005), there is little research on teacher influences with AMT (Peng et al., 2019; Prensky, 2001) and DreamBox "does not prescribe a specific role for teachers" (Wang et al, 2011).

In isolation, adaptive math technology, such as DreamBox, has been found to have a positive effective on math achievement (Cheung et al., 2013; Grams, D. 2018). However, there is a dearth of knowledge regarding true integration of this technology. In some classrooms, AMT runs concurrently with the teaching of curriculum. True amalgamation of this type of technology could have a more profound impact on student achievement. This study takes the first step to establish the practices of highly effective users of DreamBox and what their integrative practices are. The key findings in this study lay out six of those most common practices and how those practices connect to the TPACK framework for technology integration.

The strength of this work lies in the participants' practices with DreamBox and how they have integrated it into their overall teaching knowledges. Power users combine their knowledge of how students learn, the needed concept knowledges for what is being taught, and their knowledge of how the technology works. This study uses the TPACK framework as a foundation to explain the integration of technology into the classroom but centers that framework within the context of a math classroom. Identifying practice that may help teachers understand how to manipulate the AMT software to seamlessly integrate it into the overall learning environment.

Key Findings

This study adds to the findings of Callaghan et al (2018) study and contributes more information to how highly successful teachers use AMT in the classroom. It does so by establishing a new understanding of teacher AMT practices with individual students and with the class as a whole. Most importantly, this study attempts to outline the practices of highly effective teachers with AMT and how they successfully engage with the program. The following practices are based on how power users with the AMT DreamBox report to use the program in their classrooms and how those practices connect to the TPACK framework.

Pairing the Program with Current Content

The results of the study show DreamBox being used most commonly for student review of content from the current grade level and for additional practice of the content currently being taught. This is consistent with what Callaghan et al (2018) found—that the practice of reordering game objectives in AMT did have an effect on the standardized test scores at the end of the year ($p < .05$). In that study, the teachers reordered the lessons within the game to align with what was being presented in class (Callaghan et al, 2018). Reordering objectives to make the content match what is being taught in class is a practice of highly successful DreamBox users, as well.

The practice of pairing the program with the current content being taught in class focuses on using DreamBox to compliment the current content in the grade level. This is an application of the TPK aspect of the TPACK framework (Koehler et al, 2005). The teacher is using her pedagogical knowledge and her technological knowledge to integrate the program into the classroom. This is a deliberate shift from the program merely coexisting separately from the content the teacher is delivering. They are now being used collaboratively with each contributing in a congruent way to the concepts being taught.

The qualitative analysis of a coded open response question found 21 examples of teachers who indicated they paired the program with what is being taught in class. Examples of this were statements by participants who said, “I try to make short term assignments based on the content that is being taught in class” and “Pairing DreamBox with what we are learning has seemed to really help”. DreamBox aligns with the more widely used curriculum such as Eureka Math, Bridges Math, and enVision, and current lessons can be paired by the teacher, but its algorithms could not possibly account for what is presently being taught without teacher input. This is where the practice of pairing the program with current content is important and shown to be engaged in by power users who are using their pedagogical knowledge and technological knowledge to fully integrate the AMT program. One power user stated, “I can also align with Bridges math curriculum when needed or NWEA” and another reported, “I assign DreamBox, Common Core, and Envision assignments”. This pairing of content, whether a review of the current grade content or additional practice of the current content, in the Callaghan study, led to higher outcomes and in the present study proves to be what highly successful teachers are doing.

Schedule Time Daily for AMT

The practice of scheduled time for DreamBox is the practice most referred to by teachers in the qualitative data. Of 104 qualitative responses, deliberately scheduling time into the daily schedule was noted 44 times in practices with individual students, whole class, and additional practices combined, suggesting that power users intentionally schedule time for DreamBox during the school day. One power user stated, “We reserve 20 minutes of time during math rotations for DreamBox daily.” Others added “DreamBox is listed on the daily schedule…” and “Designated time for students to complete lessons”. One teacher added the detailed answer of, “I have a set routine that at 1:40 we all access DreamBox at school”. Since the most common practice from the quantitative question regarding what teachers do most frequently when accessing the dashboard is viewing the students’ time on the program, the teacher is using her TK when checking the data to verify this time usage. The qualitative analysis shows highly effective teachers are scheduling time in the day for students to use DreamBox and the Likert-type item regarding teacher practices when accessing the dashboard, confirms this when the most common practice is accessing student data to verify usage.

Although the Callaghan study did not address a time requirement for students on AMT, Gram (2016), found a minimum of 60 minutes per week of time on the program yielded gains in math. The present study found the practice of scheduling time into the school day for DreamBox is a practice of highly successful teachers.

Time/Lesson Requirement for Students

This study found power users establish for their students a required time and/or number of lessons on DreamBox. In both scheduling time and having time/lesson requirements, teachers are using TK to access their dashboard and view student usage data. They are intentional about having time/lesson requirements and making sure the data supports the requirement. Examples of this are abundant in the responses. “We required 60 minutes for a 5-day week” or “1-2 lessons a day/7-10 lessons a week (requirement)”. In each case there is a very specific time and/or lesson requirement for the student to complete. The Center for Educational Policy Research at Harvard University (2016) published a study that concluded larger gains in achievement were found for students who spend more time on DreamBox. This is consistent in quantitative data results of this study that found teachers viewing students’ time on the program and viewing students’ lessons completed, as the top two practices most engaged in. This combined with the qualitative data code, time/lesson requirement, found 34 times in the participant responses, would indicate top teachers are engaged in setting a time or lesson requirement and checking to make sure students are meeting it.

This practice differs from the practice of having daily scheduled time for DreamBox. This practice is the teacher having a requirement of each student, usually in a given amount of time (a week, a quarter, etc.). In the qualitative data, the time/lesson requirement code describes an expectation of what a student needs to complete in a given time frame. Power user statements such as, “Students work at their 'level' and are encouraged to complete 5 or more lessons a week” or “I give my 1st grade students a goal of 1 completed lesson a school day or 5 per week”, demonstrate this practice. However, it is not known how teachers in this study established this requirement.

Although no studies could be found with only a lesson per week requirement, one study found 60 minutes a week yielded gains in math and “this amount of time should equate to students making the recommended progress within the program of completing five to ten lessons per week for kindergarten through second grade and seven to eight lessons per week for third through fifth grade students” (Grams, 2017, p. 109). This code, time/lesson requirement, found 34 times in the qualitative data, is a practice of highly effective users of DreamBox in this study.

Rewards & Accountability for Students

Another practice engaged in by powers users in this study is giving rewards for meeting time or lesson goals and holding students accountable for their progress in DreamBox. This was a reoccurring code throughout the data with 57 responses referring to a reward being given or a form of student accountability. This code is defined as a teacher giving a reward for lessons, time, or standards completed, or the teacher holding students accountable for their progress and achieving their goals. This could be in the form of public acknowledgement or a more personal form of recognition. Teachers mentioned giving weekly or monthly progress reports, keeping classroom charts, giving individual certificates, or assisting students in establishing personal goals. Responses such as, “I use the standards completed in order to give students certificates; I keep parents informed of student goals; we send out mid-week progress reports” and “Mini celebrations for completion, feedback on achieving goals” demonstrate how teachers motivate students to do lessons in DreamBox. Another teacher stated, “I consistently check reports and student overviews. We celebrate accomplishments and recognize those that are completing short term assignments. I do wish there were more weekly class certificates and incentives offered by

DreamBox". Highly successful AMT teachers in this study use rewards and accountably to increase student motivation.

Rewards & Accountability were not addressed in the Callaghan study (2018), but the present study found power users are rewarding engagement in DreamBox, as well as holding students accountable for their progress. The teachers in this study referred to some kind of reward or accountability for their students 57 times in the free response questions analyzed. This extrinsic motivation from teachers in the form of certificates for accomplishments, incentives for finishing lessons, or public acknowledgement of progress, is shown to foster more engagement with AMT (Proulx et al., 2016). Research has shown students are motivated by the idea of having their accomplishments recognized and valued by their learning community (Deci et al., 1985; Malone et al., 1987). This was also found in the quantitative data when teachers were asked about how they reward their students. With the most used practice of publicly acknowledging lessons completed and/or growth achieved, this extrinsic motivator aligns with research on learning communities. Power users are holding their students accountable by setting goals and checking their progress. Highly effective teachers with AMT are rewarding students for progress in the program in a highly public way by acknowledging the achievements of their students to the greater learning community—the classroom.

Understanding what motivates specific students speaks to the teacher's knowledge of students and is tied into the TPACK framework through the context aspect (Koehler et al., 2005; Rosenberg et al., 2015). When teachers use motivators to increase usage of the program, rewards for accomplishments, and accountability measures, they are contributing to the overall context, a situated form of knowledge and also a component of the TPACK framework (Koehler et al., 2005).

Assigning Lesson to Fill in Gaps & Enrichment

This practice is when a teacher assigns lessons from previous grades to fill in gaps or for enrichment, a teacher assigning lessons to extend the learning of a concept for grades beyond. This study addresses these to behaviors together because they both involve assigning lessons outside the current grade level, below or above.

Using AMT to fill in gaps in a student's learning has been noted in past research (Peng et al., 2019). This is a function of the program itself. Although a function of the program is to adapt to the needs of the user (Peng et al., 2019), power users indicate their knowledge of current or upcoming content drives the assigning of lessons. Again, this is an example of TPK. Integrating the AMT into the role of reteaching missed concepts or teaching new concepts that are above level. In both cases the teacher is steering the program where she needs it to go based on her PK. The teacher is taking this function away from the program and assigning the lessons (TK) they want their students to engage in. In this way the teacher is using DreamBox for individual differentiation of learning. This statement from a teacher explains her thinking and practice for filling in conceptual gaps:

> Since I teach 3rd grade, I feel it is a gate keeping grade. It is imperative that my students understand everything from k-3 by the end of the year since 4th grade starts application with no real review. By using DreamBox, I can tell what holes are missing in my students learning from prior grades. From the first day of the year, I begin to assign any unmastered work from prior grades.

This practice of filling in gaps makes it possible to tailor student experiences with AMT to the individual needs of each student. Another teacher added, "For example if a student is missing 1st, 2nd, and 3rd grade standards from O.A., I will start with the 1st grade missing standards and have them work towards grade level". This points to a deliberate use of lessons within the program to target a student's missing concept knowledge. The teacher is manipulating the program when a concept is presented and driving the direction of the content within the program.

In the practice of enrichment, teachers recognized an opportunity to increase conceptual knowledge above what is currently being taught. One teacher stated, "I love the ability to push students that are above grade level to harder material so they can work at their own pace on harder content.". In this way, teachers are assigning lessons to enrich what the student has mastered and move on to the next level without compromising the focus of the class as a whole. This practice is explained by one teacher, "If a child has already mastered that skill, I will assign that skill at the next grade level or an extension lesson". This use of the program for enrichment shows teachers assigning higher level continuation of concept learning.

The Callaghan et al (2018) study stated teachers used the AMT to identify struggling students, however, it did not establish the teachers in the study actively assigned lessons to address the lacking concept or skill the students were struggling with. This is a practice the highly effective users of AMT take further than the average AMT teacher user. In this way, the power user drives the technology in a deliberate and focused way, not only identifying a need a student has but manipulating the technology to assist them in addressing the gap in learning for the individual learner.

The Callaghan study did, however, address the next practice discovered in the present study, identifying students having difficulty and holding help sessions to intervene.

Identifying Students Having Difficulty & Holding Help Sessions

The teachers in the Callaghan et al (2018) study used the data to “initiate a conversation” with that student. “Teachers stated that the reports helped them pinpoint students who did not ask for help by showing them which areas students continuously struggled with in the game” (Callaghan et al, 2018, p. 16). As with that study, the present study found this practice as well. The findings for this practice rely heavily on the qualitative data analyzed. The Likert scale question, *what do you do when a student has difficulty with a DreamBox lesson*, did not address the identification of students, and so this practice of identifying students emerged in the data from statements such as, “I really enjoy assignments because it allows me to see progress and if someone is struggling in that area. When I see that someone is struggling, we have a conversation and sometimes I find that there are other reasons”. In this way, the teacher is looking at the data, identifying a problem area, and addressing it on an individual basis. This type of response was echoed as teachers expressed the use of DreamBox data as an additional point of contact for understanding where a student is in their conceptual learning. One teacher noted:

> “As students work in DreamBox, I watch the class using Google Classroom. I intervene when I notice a student struggling to understand the nature of what they are to do. (i.e. doesn't know where to click, doesn't recognize what a word means, cannot figure out what the question is asking and making repeated mistakes). I also use the notification that a student is struggling with an assignment to form small groups”.

This quote speaks to the other part of this practice, holding help sessions. Another response indicated, “I hold DreamBox help sessions in the afternoons for students who are struggling,” while another teacher noted use of “small group instruction based on strugglers.” Power users are using the data DreamBox provides to pinpoint concepts their students are struggling with, to engage in small group or individual interventions.

Teacher Practices and TPACK

TPACK is a framework for the synergistic integration of technology, pedagogy, and content, in context, for the purposes of learning design (Mishra & Koehler, 2006; Angeli & Valanides, 2009). As stated earlier, the TPACK framework situates technological pedagogical knowledge as the intersection of the technological knowledge and pedagogical knowledge. Looking at the practices most engaged in by power users of DreamBox in this study in the context of the TPACK framework can lead to a greater overall understanding of how those practices contribute to the successful integration and use of AMT. This study builds on examples of how teacher's knowledge of pedagogy is integrated with their technological knowledge. The TPK part of TPACK informs the practice of using technology to produce data to direct the how the teacher interacts with the content and the student in pairing the current content with the AMT as well as supporting what each student needs.

Implications for Practice

These results of this study have implications for current AMT users. Understanding not only how the AMT program works, but also how it fits pedagogically and contextually within the overall framework of the classroom instructional model, is essential to successfully implementing it in the classroom. As stated earlier, an AMT program can run its intended algorithms to adapt to the student's needs without teacher intervention. However, this study has addressed what highly successful AMT teachers' practices are. These teachers "sit in the driver's seat" by pairing lessons with current content, assigning lessons for student review of current content, and assigning lessons to fill in gaps or provide enrichment, power users are indeed driving the content of the program. Given the findings of this study that show connections between teacher practices and the TPK component of TPACK, teachers may benefit from PD that included *how* to drive the program for complete integration.

Professional Development

The findings from this study contribute to the creation of effective professional development that provides K-6 teachers with necessary knowledge and skills to collaborate with AMT in a way that increases student outcomes. Callaghan, et al (2018) established the desire of teachers using AMT for PD, this study contributes to the content of that PD. Effective professional development should focus on the *how* to pair current content with the AMT based on TPK with an additional focus on student use of the AMT.

Focus: How to Pair Content.

Paring the content with the classroom curriculum is becoming increasingly more user friendly. DreamBox and other AMT programs are consistently increasing the curriculum options teachers can access through the dashboard. This is facilitating the accessibility of lesson choices that have the concept or skill the teacher wants the student to engage in.

PD should add to teacher's knowledge of the data the program provides and how to ascertain when a student is missing a concept or skill and what supportive lessons would help fill in a gap in the student's learning. Understanding the data would also allow a teacher to see what concepts a student is struggling with. This study showed power users use the data to identify students who are having difficulty with a lesson. They assign supportive lessons or hold help sessions. Effective PD would address this practice and offer solutions for teachers when a difficulty is discovered.

Focus: Ensuring Student Use.

Another component of PD should be to help teachers understand the practices of this study focusing on student use; deliberately scheduling AMT time in the daily schedule, having time/lesson requirements, and having a system of rewards and accountability. Power users engage in these practices and use the data the program affords to confirm students are working through lessons and spending the required time expected.

Figure 2 details both suggested practice components for teachers using AMT. Three practices focus on how to pair current content with AMT based on what the present study found and how the practices relate to TPK. This study suggests PD include the practices found in this study related to ensuring student use of the program. These practices are listed in Figure 2.

Limitations and Future Research

More research is needed on this topic. This work establishes the practices of highly effective (top 10%) teachers with AMT. However, what are teachers who do not get as much growth doing? How are they using AMT? Research is needed at all levels. One limitation of this study is the participants are all high users of the program. Teachers in other student growth categories may or may not have the same practices.

Barriers to Integration

This study did not address low performing teachers–those with low average student growth in AMT programs. It does not look at possible barriers to integrating technology such as the first order barriers discussed earlier, which include barriers to resources (hardware and software), support (administrative and technical), and training or second order barriers, including confidence, beliefs and perceived value (Ertmer, et al 2012). If either of these types of barriers are present, they need to be addressed and resolved before full integration can occur.

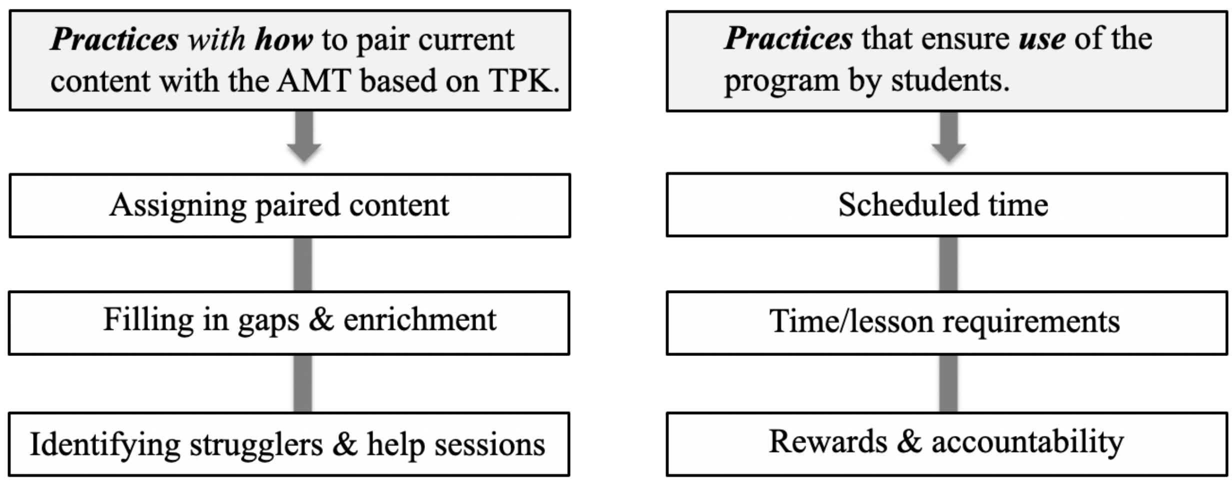

Figure 2. Suggested Practices for Professional Development

Teacher or Student Population?

Additional research needs to be conducted on the amount of growth students obtain in a given teacher's classroom from year to year. This study is limited to a snapshot in time. One study found, "Even though the students differed from year to year, patterns of usage in a given teacher's classroom remained similar" (Center for Educational Policy Research, Harvard University, 2016). Following student growth in a specific teacher's classroom for several years would better establish what the practices of that teacher are and if those practices influence student growth regardless of the student.

Grade Level Differences

This study established the practice by successful teachers of having time and/or lesson requirements. DreamBox suggests 60 minutes a week of time on the program and other studies have confirmed its effectiveness for this time allotment as well (Grams, 2017). But how does this need change with grade level? A study to individualize optimal grade level time on the program would be beneficial in helping teachers understand where to set the time requirements.

In addition, understanding the different mathematical needs of a kindergarten student as opposed to a 5^{th} grade student is important. This study looked at all power users without regard to the grade they teach. The practices of a kindergarten teachers with AMT may not be the same as a 5^{th} grade power user because these groups of students have very different needs. More research needs to be conducted to study the difference and establish grade-specific practices with AMT.

Preservice Teacher Preparation

More research regarding what preservice teachers need to successfully use adaptive technology before entering the classroom would contribute to how we train aspiring educators.

Best practices with AMT need to be fully established and added to the educational technology training for preservice teachers as well as technical training with the program to understand the data available and how to use it. This may need to include general transferable knowledge of use. The AMT programs sold to districts today vary in what components are available and how to collect data and manipulate target lessons or standards, but all have a central location for the teacher to use to drive the system. A basic understanding of a dashboard, the data, and of the TPK aspect of TPACK as it relates to AMT, would be helpful.

Teacher Content Knowledge

Future studies should examine the influence of teacher content knowledge and integration of and collaboration with AMT. The data in the study did not specifically address the teacher knowledge component of TPACK, however, more research is needed to discover how a teacher's overall level of content knowledge influences engagement with and manipulation of the program.

Conclusion

This study has identified the practices of highly successful teachers with AMT. The 21st century classroom is an amalgamation of teacher and technology. Learning how to best use AMT is more than just knowing how to sign into the program and use the tools (TK), it is about understanding how to integrate the engaging game-like content of the program with the classroom curriculum (TPK) in a way that increases student outcomes.

The TPACK framework identified the knowledge a teacher needs to successfully integrate technology into the modern classroom (Mishra & Koehler, 2006). With that framework as a guide, this study identifies the practices of teachers successfully integrating a specific technology, DreamBox, and how they interact with it pedagogically (TPK). The results are suggestions for practices with AMT, (1) pairing lessons with current content being taught (2) having daily scheduled time for AMT, (3) time/lesson requirement for students, (4) a system of rewards & accountability, (5), assigning lessons to fill in gaps & enrichment, and (6) identifying students struggling & holding help sessions. As AMT becomes more widely used in the elementary classroom, knowledge of integration and best practices will be essential.

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Appendix A
Teacher influence with adaptive math technology

Hello: You have been identified as an educator who demonstrates an extremely high average student growth rate with DreamBox Learning. You are invited to participate in our survey, Teacher practices with adaptive math technology. Teachers will be asked to complete a survey that asks questions about what behaviors they engage in when interacting with the adaptive math technology, DreamBox.

- It will take approximately 10-15 minutes to complete the questionnaire.
- Your participation in this study is completely voluntary.
- There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. It is very important for us to learn your practices.
- Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate.
- Your information will be coded and will remain confidential.

If you have questions at any time about the survey or the procedures, you may contact Jennifer Longnecker by email at jlongne1@vols.utk.edu or contact the University of Tennessee, IRB Compliance Officer at (865-974-7697; utkirb@utk.edu). Thank you very much for your time and support. Please start with the survey now by clicking on the Next button below.

Section 1

1. Are you currently using adaptive math technology (DreamBox) in your classroom?
   - o Yes
   - o No

2. Which students in your classroom use/access DreamBox?
   - All students use/access DreamBox
   - Only students receiving intervention support (e.g., RTI, MTSS, or other programs) use DreamBox
   - Other, please specify ___________

3. How are you currently using DreamBox?

	Unsure	Never	Once in a while	Most of the time	Always
For Student review of content from prior grades	❑	❑	❑	❑	❑
For Student review of content from the current grade	❑	❑	❑	❑	❑
For enrichment	❑	❑	❑	❑	❑
To teach new content	❑	❑	❑	❑	❑
For additional practice of current content	❑	❑	❑	❑	❑
To teach background material that the student did not previously learn.	❑	❑	❑	❑	❑
Other, please explain other practices below	❑	❑	❑	❑	❑

4. Does your school require all students to use DreamBox?
   - Yes, all students with DreamBox licenses are required to use DreamBox
   - No, DreamBox is optional for students
   - Prefer not to answer

5. What device access do your students have to DreamBox?

	Unsure	No Students	Some Students	Most Students	All Students

Individual device access at school	❑	❑	❑	❑	❑
Shared device access at school	❑	❑	❑	❑	❑
Computer lab access at school	❑	❑	❑	❑	❑
Individual device access at home	❑	❑	❑	❑	❑
Shared device access at home	❑	❑	❑	❑	❑

6. Please complete the following statements.

	Unsure	Less than once a week	1 day a week	2-3 days a week	4-5 days a week	6-7 days a week
I access the dashboard.	❑	❑	❑	❑	❑	❑
My students access DreamBox after school hours.	❑	❑	❑	❑	❑	❑
My students access DreamBox during school hours.	❑	❑	❑	❑	❑	❑

7. When you access your teacher dashboard on DreamBox, what are your practices with regard to individual students?

	Unsure	Never	Once in a while	Most of the time	Always
I view lessons completed.	❑	❑	❑	❑	❑
I view total amount of time on the program.	❑	❑	❑	❑	❑
I view standards completed.	❑	❑	❑	❑	❑
I view growth (Student Overview).	❑	❑	❑	❑	❑
I view the student's Activity Feed	❑	❑	❑	❑	❑
I make short-term assignments for an individual student.	❑	❑	❑	❑	❑
I make long-term assignments for an individual student.	❑	❑	❑	❑	❑
I remove/cancel assignments.	❑	❑	❑	❑	❑
I look at student performance on short-term assignments.	❑	❑	❑	❑	❑
I look at student growth on long-term	❑	❑	❑	❑	❑

assignments.					
I use the student messaging feature to communicate with the student	❑	❑	❑	❑	❑
Other, please add other practices below	❑	❑	❑	❑	❑

8. Please explain what classroom practices or routines you find most helpful and how those practices impact individual student progress in DreamBox.

9. When you access you teacher dashboard on DreamBox, what are your practices with regard to the class as a whole?

	Unsure	Never	Once in a while	Most of the time	Always
I view lessons completed.	❑	❑	❑	❑	❑
I view total standards completed.	❑	❑	❑	❑	❑
I view standards completed.	❑	❑	❑	❑	❑
I view the Activity Feed.	❑	❑	❑	❑	❑
I make short-term assignments.	❑	❑	❑	❑	❑
I make long-term assignments.	❑	❑	❑	❑	❑
I remove/cancel assignments.	❑	❑	❑	❑	❑
I look at student performance on short-term assignments.	❑	❑	❑	❑	❑
I look at student growth on long-term assignments.	❑	❑	❑	❑	❑
I use the student messaging feature to communicate with students.	❑	❑	❑	❑	❑
Other, please explain other practices below.	❑	❑	❑	❑	❑

10. Please describe any other classroom practices or routines that you engage in with regard to the class as a whole.

11. Do you demo the games in the program?

- ○ Yes
- ○ No
- ○ Prefer not to answer

12. For what reason(s) do you demo a game in DreamBox?

	Unsure	Never	Once in a while	Most of the time	Always
To help a student with the user-interface (knowing how to use a virtual manipulative or game)	❑	❑	❑	❑	❑
To understand how the tools work within the game	❑	❑	❑	❑	❑
To learn strategies to play the game	❑	❑	❑	❑	❑
To learn new strategies for presenting a concept	❑	❑	❑	❑	❑
To model math strategies in a game (whiteboard)	❑	❑	❑	❑	❑
To help a student with conceptual understanding	❑	❑	❑	❑	❑
To help a student with procedural skills.	❑	❑	❑	❑	❑
To analyze the game for math concepts (to supplement current curriculum)	❑	❑	❑	❑	❑
To learn new content knowledge	❑	❑	❑	❑	❑
To refresh content knowledge	❑	❑	❑	❑	❑
For enjoyment	❑	❑	❑	❑	❑
To connect with students	❑	❑	❑	❑	❑
Other, please explain below	❑	❑	❑	❑	❑

13. Please explain your classroom practice(s) or routines not listed with regards to playing a demo lesson.

14. To what extent do you agree with the following statement: Playing demo lessons has enhanced my content knowledge.

    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

15. In what ways has playing demo lessons on DreamBox enriched your content knowledge?

16. What other classroom practices do you engage in when using DreamBox?

17. What do you do when a student has difficulty with a DreamBox lesson?

	Unsure	Never	Once in a while	Most of the time	Always
I let DreamBox adapt with scaffolding as it was designed to by reminding students to click the “Help” and “Hint” buttons as well as answer the question a few times and listen to the DreamBox feedback when they are incorrect.	❑	❑	❑	❑	❑
I help the student with the lesson while they are in the lesson.	❑	❑	❑	❑	❑
I have another student help the student with the lesson.	❑	❑	❑	❑	❑

I don’t do anything.	❑	❑	❑	❑	❑
I assign a supportive DreamBox lesson.	❑	❑	❑	❑	❑
I help the student using a DreamBox demo lesson accessed through my teacher dashboard	❑	❑	❑	❑	❑
I use paper, a whiteboard, or chalkboard to help the student.	❑	❑	❑	❑	❑
Other, please explain below	❑	❑	❑	❑	❑

18. Please explain what classroom practice(s) or routines you find most helpful and how they impact student growth when helping a student having difficulty with a lesson?

19. How did you learn to use and implement DreamBox?

20. To what extent do you agree with the following statement: During my pre-service teacher training, I learned to effectively use and implement adaptive math technology in the classroom.

    - Strongly Disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly Agree

21. What do you do when need assistance with DreamBox?

	Unsure	Never	Once in	Most of	Always

			a while	the time	
Search online (i.e., YouTube, videos)	❑	❑	❑	❑	❑
Search DreamBox’s website	❑	❑	❑	❑	❑
Access DreamBox’s help features and support materials available in the dashboard	❑	❑	❑	❑	❑
Ask another teacher	❑	❑	❑	❑	❑
Contact your DreamBox contact or PD Specialist	❑	❑	❑	❑	❑
Ask your building or district math leader	❑	❑	❑	❑	❑
Ask your technology professional (in your school)	❑	❑	❑	❑	❑
Ask a student	❑	❑	❑	❑	❑
Other, please explain below	❑	❑	❑	❑	❑

22. What other practice(s) do you engage in if you need assistance with DreamBox?

23. How do you motivate your students to use DreamBox?

	Unsure	Never	Once in a while	Most of the Time	Always
I give a reward for lessons completed	❑	❑	❑	❑	❑
I give a reward for growth in math concepts	❑	❑	❑	❑	❑
I publicly acknowledge lessons completed and/or growth achieved (i.e., with a chart on the bulletin board or weekly email to the class)	❑	❑	❑	❑	❑
Other, please explain below	❑	❑	❑	❑	❑

24. What motivators, if any, do you find most helpful for increasing student weekly lesson completion?

25. What motivators, if any, do you find most helpful for increasing student growth in math concepts?

26. Is there anything else you do that would add to our understanding of your practices with DreamBox? Please give as much information as possible.

27. Do you participate in or contribute to any of the options listed below?

	Unsure	Never	Once in a while	Most of the time	Always
A DreamBox sponsored blog	❑	❑	❑	❑	❑
A DreamBox sponsored webinar	❑	❑	❑	❑	❑
DreamBox on Facebook	❑	❑	❑	❑	❑
DreamBox on Instagram	❑	❑	❑	❑	❑
DreamBox on Twitter	❑	❑	❑	❑	❑
DreamBox on LinkedIn	❑	❑	❑	❑	❑
DreamBox Nation	❑	❑	❑	❑	❑
DreamBox Innovation Council	❑	❑	❑	❑	❑

Section 2

Demographic Information

The following demographic questions are optional but will help the researcher understand your answers.

28. What is your age?

29. How many years have you been teaching?

30. What grade level do you teach?

- K
- 1
- 2
- 3
- 4
- 5
- Other ___________

31. How many years have you used DreamBox in your classroom?

32. According to your dashboard, what is your average lessons per week for your class on DreamBox in the current school year?

33. How would you categorize your school? (Select only one)

- Rural
- Urban
- Suburban
- Charter
- Other
- Prefer not to answer

34. Which of the following best describes your school? (Select only one)

- Public non-charter
- Public charter
- Private religious
- Private non-religious
- Other
- Prefer not to answer

Appendix B
Expert Recruitment Email

The following information is provided to inform you about this assessment expert review project and your participation in it. Please read this form carefully and feel free to ask any questions you may have. Your participation is voluntary and there is no penalty for refusing to participate in the study.

INTRODUCTION

Hello, and thank you for your interest in providing your expert review of my assessment! My name is Jennifer Longnecker, and I am interested in learning more about what teacher practices influence student growth in adaptive math technology. I would like to first gather feedback from expert reviewers on my surveys that will be given to participants in a future research project. There are minimal risks to this study and responses will be kept completely confidential by the researchers. If you would be interested in providing your expert review of my survey, please continue reading the consent form below.

You are being invited to participate in a research study. The information is provided to you about the study. Please read this form carefully. Your participation is voluntary. You are also free to withdraw from this study at any time. I would like to invite you to 1) evaluate a survey that will be similar to what will be utilized in a future study. Each assessment expert reviewer will receive a $20 Amazon gift card for the task in compensation for sharing their time and expertise.

INFORMATION ABOUT PARTICIPANTS' INVOLVEMENT IN THE STUDY

This research study consists of a confidential survey asking about your evaluation. Additionally, you will be asked on the survey if you would like to be contacted if the researchers have follow-up questions about your evaluation answers. The evaluation and survey should take you approximately 30 minutes to complete.

RISKS

The level of risks associated with the current study are minimal. You may feel uncomfortable sharing your opinions; however, please know that all responses will be kept completely confidential by the researchers. Please answer as honestly as possible in order to provide the most accurate information. However, if you have a feeling of discomfort at any time, you may choose to terminate your participation in the study.

BENEFITS

The researcher hopes the assessment expert reviewers might benefit from the information collected, as their feedback will be used to improve the assessment utilized in a future study on what teacher practices influence student growth in adaptive math technology. The information from this study will be utilized to inform teacher practices with adaptive math technology.

COMPENSATION FOR PARTICIPATION

In compensation for sharing your time and expertise with the research team on this task, you will be provided with a $20 Amazon gift card. The gift card will be available to pick up at the University of Tennessee or sent to you via mail, depending on your preferences.

CONFIDENTIALITY

The information you provide on the surveys will be kept completely confidential. Only the researchers will have access to your answers and the data will be stored on the secure password protected computers owned by the study's researcher and/or the University of Tennessee. The information you include in this consent form will also be stored on the secure password protected computers owned by the study's researcher and/or the University of Tennessee. No references will be made in any reports that could link you as a participant to the study or the data.

Your information may be used for future research studies or shared with other researchers for use in future studies without obtaining additional informed consent from you. If this happens, all of your identifiable information will be removed before any future use or sharing with other researchers.

CONTACT INFORMATION

If you have questions at any time about the study or the procedures, you may contact the researcher at the University of Tennessee: Jennifer Longnecker (jlongne1@vols.utk.edu). If you have questions about your rights as a participant, contact the University of Tennessee, IRB Compliance Officer at (865-974-7697; utkirb@utk.edu).

PARTICIPATION

Your participation in this study is completely voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty. If you become uncomfortable sharing your evaluation feedback during the survey, then you are free to skip any question or stop the survey at any time without penalty and without any loss of benefits to which you are otherwise entitled. If you choose not to turn in your responses to the researchers after answering the survey questions, your data will be destroyed and will not be used in any data analyses. If you decide to finish the surveys, know that all data obtained will be collected with confidentiality.

____

CONSENT

I have read and understood the above information. I have had the opportunity to print a copy of this form. I agree to be an assessment expert reviewer in this study.

X ____ ________________________

Signature of Participant Date

X ____ ________________________

Signature of Researcher Date

Appendix C
Validation Feedback

Question	Validator Feedback	Resolution
3 How are you currently using DreamBox?	V2 [a]: Adding "past content" for the first option might help distinguish between practing [sic] past and current content. DB [b]: Add past content/background knowledge	Added as a choice, “To teach background material that the student did not previously learn”. See above.
7 When you access your teacher dashboard on DreamBox, what are your practices with regard to individual students?	V1 [c]: It may be a good idea to specify that you are talking about the DreamBox Teacher Dashboard. V2: On the scale questions, do you want them to explain other practices in the next short answer item? I think this could be confusing if multiple practices are described and only one answer can be selected. Can you add another question or more information in the directions about if you add more than one practice, please specify how often you use each practice. V7 [d]: Need the words “individual students” bolded to make sure the reader is clear.	Reworded the question to add, “Teacher dashboard” Changed to a Likert-scale format. The participant rates each practice on a 4-point scale with an additional option of “Unsure” “Individual students” bolded
15 In what ways has playing demo lessons on DreamBox enriched your content knowledge?	V7: Perhaps a box for “if not at all what improvements do you feel would need to be made in order for the Dreambox games to enchants your own content knowledge?” DB: Add, “the phrase ‘user-interface’ and ‘knowing how to use a virtual manipulative or game’ to the first practice	I opted not to add this because I did not feel it related to teacher practices. Reworded to: “to help a student with user-interface (knowing how to use a virtual manipulative or game)”
17 What do you do when a student has difficulty with a DreamBox lesson?	DB: Change the word “struggles” to has difficulty with. DB: Suggestion: “I let DreamBox adapt with scaffolding as it was designed to by reminding students to click the “Help” and “Hint” buttons as well as answer the question a few times and listen to the DreamBox feedback when they are incorrect.”	Wording changed to eliminate the word, “struggles” Added this in the Likert-scale choices as I wasn’t aware of the “Help” or “Hint” features.

28, 29 & 31 What is your age? How many years have you been teaching? How many years have you used DreamBox in your classroom?	V6 [e]: On the last questions that ask about teacher's age, how long teaching, how long using Dreambox... Maybe provide a choice of age range (maybe 20-29, 30-39, 40-49, 50+), range of years teaching (1-5 years, 6-10 years, 11-20 years, 21+ years), range of how long using Dreambox (1-2 years, 3-5 years, 6+ years). I wasn't sure how long, so I was going to put 4 or 5 years, but it would only accept numerical values so I couldn't type in "or" or "years."	I chose to leave these questions as fill in the blank and not a range for future data analysis.
32 According to your dashboard, what is your average lessons per week for your class on DreamBox in the current school year?	DB: This metric was removed from the new dashboard, but we still have it to ID teachers for the study. And we're working on a replacement metric.	The question did read, "According to your dashboard, what is your average student growth on DreamBox in the current school year?"

Note. Validator 2 [a]. DreamBox feedback [b]. Validator 1 [c]. Validator 7 [d]. Validator 6 [e].
All feedback from Validators 3, 4, and 5 was not content related.

Appendix D
Recruitment Letter for DreamBox Power Users

Dear Power User of DreamBox,

My name is Jennifer Longnecker, and I am a doctoral student at the University of Tennessee, enrolled in the Theory & Practice in Teacher Education program with a cognate in Educational Technology. For my dissertation, I am conducting an exciting study on what practices the highest preforming teachers engage in with the adaptive math technology, DreamBox. I am writing to request your participation as a power user of this program. Because you are in the top 10% of teachers who see the most student growth, I am hoping to get your support for my study.

Contained in this correspondence is a link to a survey. The window to take the survey will be from (insert date here) to (insert date here). The survey should only take around 10-15 minutes to complete the questionnaire and your participation in this study is completely voluntary. Understanding what you are doing with DreamBox in your classroom will greatly help other teachers understand what works and will contribute to what we know about best practices with adaptive math technology.

If you are interested in participating, please click on this survey link to start. Thank you for your time and insight into this powerful technology.

Best,

Jennifer Longnecker
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Appendix E
Follow up Reminder for the Survey

Dear DreamBox Power User,

This is a friendly reminder the window to take the survey will close in one week. If you have not completed the survey (linked), please do so by (insert date here). Thank you for your time with this valuable research.

Best,

Jennifer Longnecker
PhD Candidate &
Graduate Teaching Associate, College of Education
Department of Theory & Practice in Teacher Education
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Appendix F
Qualitative Codebook

Question 8: Please explain what classroom practices or routines you find most helpful and how those practices impact individual student progress.

Codes	Definition	Examples
Scheduled time (28)	Teacher has intentional scheduled time for DreamBox; Daily DreamBox time	A scheduled time for DreamBox; We reserve 20 minutes of time during math rotations for DreamBox daily
Time/lesson requirement (21)	Teacher has a set required time/number of lessons on DreamBox; Teacher sets goal for time or lessons completed	We required 60 minutes for a 5-day week; Our goal is to complete 6 lessons a week.
Fill in gaps & enrichment (19)	Teacher assigns lessons from previous grades to fill in gaps; Teacher assigns lessons to fill in grade level gaps; Teacher assigns lessons for grades beyond.	It really helps fill in gaps from previous years; I assign long term assignments from prior grade levels to fill the gaps; When they approach grade level, they get grade level assignments; I fill gaps in other content areas that we will be moving into; When they approach grade level, they get grade level assignments and beyond;
Identify strugglers & help sessions (15)	Teacher uses assignments/data to identify students struggling; Teacher schedules help sessions for DreamBox lessons. Teacher works with the student to help solve problems with a game.	I really enjoy assignments because it allows me to see progress and if someone is struggling in that area; I hold DreamBox help sessions in the afternoons for students who are struggling
Rewards & accountability (23)	Teacher gives a reward for lessons/time/standards completed. Teacher holds students accountable for their progress and achieving their goals.	I use the Standards completed in order to give students certificates; I keep parents informed of student goals; We send out mid-week progress reports
Pairing with current content (11)	Teacher pairs what she is teaching in class with the corresponding standard on DreamBox.	Pairing DreamBox with what we are learning has seemed to really help.

Early finisher	Teacher has students who finish work early work on lessons in DreamBox.	I use DreamBox as an early finisher work and a before school activity.

Question 10: Please describe any other classroom practices or routines that you engage in with regards to the class as a whole.

Codes	Definition	Examples
Scheduled time (15)	Teacher has intentional scheduled time for DreamBox; Daily DreamBox time	A scheduled time for DreamBox; We reserve 20 minutes of time during math rotations for DreamBox daily
Time/lesson requirement (11)	Teacher has a time or lesson expectation for the class.	We require 60 minutes for a 5-day week; Our goal is to complete 6 lessons a week.
Fill in gaps & enrichment (6)	Teacher assigns lessons from previous grades to fill in gaps; Teacher assigns lessons to fill in grade level gaps; Teacher assigns lessons for grades beyond.	It really helps fill in gaps from previous years; I assign long term assignments from prior grade levels to fill the gaps; When they approach grade level, they get grade level assignments;
Rewards & accountability (20)	Teacher gives a reward for lessons/time/standards completed. Teacher holds students accountable for their progress and achieving their goals.	I use the Standards completed in order to give students certificates; I keep parents informed of student goals; We send out mid-week progress reports
Grouping Students & peer coaching (5)	Teacher uses data to group students; Teacher sets up student to student assistance.	I use it to monitor where I need to pull students for small group instruction; Peer coaching
Pairing with current content (4)	Teacher connects DB lesson with current content being taught. Teacher assigns whole class lessons based on current content.	Pairing DreamBox with what we are learning has seemed to really help; I try to make short term assignments based on the content that is being taught in class.

Question 16: What other classroom practices do you engage in when using DreamBox?

Codes	Definition	Examples
Scheduled time (1)	Teacher has intentional scheduled time for DreamBox; Daily DreamBox time	A scheduled time for DreamBox; We reserve 20 minutes of time

		during math rotations for DreamBox daily
Time/lesson requirement (2)	Teacher has a time or lesson expectation for the class.	We require 60 minutes for a 5-day week; Our goal is to complete 6 lessons a week.
Identify strugglers & help sessions (10)	Teacher uses assignments to identify students struggling; Teacher schedules help sessions for DreamBox lessons. Teacher works with the student to help solve problems with a game.	I really enjoy assignments because it allows me to see progress and if someone is struggling in that area; I hold DreamBox help sessions in the afternoons for students who are struggling
Fill in gaps & enrichment (4)	Teacher assigns lessons from previous grades to fill in gaps; Teacher assigns lessons to fill in grade level gaps; Teacher assigns lessons for grades beyond.	It really helps fill in gaps from previous years; I assign long term assignments from prior grade levels to fill the gaps; When they approach grade level, they get grade level assignments;
Rewards & accountability (14)	Teacher gives a reward for lessons/time/standards completed. Teacher holds students accountable for their progress and achieving their goals.	I use the Standards completed in order to give students certificates; I keep parents informed of student goals; We send out mid-week progress reports
Pairing with current content (6)	Teacher connects DB lesson with current content being taught. Teacher assigns whole class lessons based on current content.	Pairing DreamBox with what we are learning has seemed to really help; I try to make short term assignments based on the content that is being taught in class.

Vita

Jennifer Longnecker grew up in Dallas, Texas and graduated from Texas A&M University in 1989 with a Bachelor of Science degree in Psychology. She later attended the University of Tennessee where she earned a Master of Science degree in Urban Multicultural, Elementary Education in 2014. Upon receiving her master's degree, Longnecker began teaching in the elementary setting spending time teaching 1st grade in Knox County, TN and time teaching 4th grade math in Oak Ridge, TN. In 2018, she returned to the University of Tennessee to begin her doctoral work in Elementary Education with a cognate in Educational Technology. As a Graduate Teaching Associate, Longnecker taught Educational Technology at UT for three years as well as one semester as a secondary instructor in Reading Education.

As part of a research team under the direction of Dr. Joshua Rosenberg, Longnecker participated in several studies focusing on Data Science in Education as well as the integration of Computer Science Standards in K-12 curriculum. Additionally, she participated in several studies with teachers and preservice teachers to study the needs in STEM content areas with regards to technology. Longnecker's current research interests are teacher involvement with digital game-based learning in the elementary math classroom.